REPORT RESUMES

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STRATEGIES OF LEARNING AND EFFICIENCY OF CONCEPT ATTAINMENT BY INDIVIDUALS AND GROUPS.

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AN ATTEMPT WAS MADE TO IDENTIFY AND CLASSIFY THE STRATEGIES OF INDIVIDUALS AND GROUPS IN ATTAINING CONCEPTS AND TO RELATE THE VARIOUS STRATEGIES TO EFFICIENCY OF LEARNING. THE PROJECT, CONSISTING OF A SERIES OF 10 EXPERIMENTS, WAS CARRIED OUT OVER A 3-YEAR PERIOD. IN EACH SUCCESSIVE SEMESTER AND SUMMER SESSION, STUDENTS ENROLLED IN EDUCATIONAL PSYCHOLOGY PARTICIPATED IN THE EXPERIMENTS AS INDIVIDUALS OR AS MEMBERS OF GROUPS OF VARYING SIZE. EXPERIMENTS WERE CONDUCTED TO DETERMINE THE SIZE AT WHICH THE MEAN EFFICIENCY OF GROUPS IS LESS THAN THE MEAN EFFICIENCY OF INDIVIDUALS WORKING ALONE. IN ADDITION TO GROUP SIZE, THE TYPE OF MATERIAL IN WHICH THE CONCEPTS ARE EMBEDDED, TYPE OF INSTRUCTION, AND THE MEANINGFULNESS OF THE TASKS WERE SYSTEMATICALLY MANIPULATED TO DETERMINE THEIR EFFECTS UPON THE DEPENDENT VARIABLES--STRATEGIES OF LEARNING AND EFFICIENCY OF PERFORMANCE. FIVE HYPOTHESES WERE TESTED. A DISCUSSION OF THE DIFFICULTY CHARACTERISTICS AND EFFECTS OF SELECTED VARIABLES ON INFORMATION PROCESSING AND INFORMATION UTILIZATION DURING CONCEPT ATTAINMENT IS INCLUDED. (JC)

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Strategies of Learning and Efficiency of Concept Attainment by Individuals and Groups

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STRATEGIES OF LEARNING AND EFFICIENCY OF CONCEPT ATTAINMENT BY INDIVIDUALS AND GROUPS

INTRODUCTION

One type of concept is the inferences that one has formed of objects or events that enable one to categorize them as belonging to the same class and to associate the relevant observable and unobservable class attributes to them and to other members of the same class. Some functions of concepts of the categorizing type are generally acknowledged. Possessing a concept enables the individual to categorize objects and events as belonging to the same class or not belonging to it; in turn, this renders the environment less complex. Furthermore, by possessing certain concepts, the individual can identify more readily new objects as he encounters them. Because values are involved in categorizing, concepts direct the individual's activities when he encounters instances of the concepts. Finally, concepts enable the individual to find meanings and relationships among classes of objects and events, rather than merely individual objects and events. A principal task of the individual in the various subject fields in school and in informal settings is the learning of concepts of the categorizing type.

Although concept learning is of highest importance in human behavior, the cognitive processes involved in the learning of concepts are not yet well understood. The many variables associated with efficiency of learning concepts are also not clarified well. The primary objective of this study was to clarify the processes in concept learning and some variables related to efficiency of learning.

The hypotheses of the present study will be clarified in connection with a brief review of the literature.

a. The strategies which individuals and groups use in attaining concepts are related to the efficiency of attaining concepts.

Hull (1920) established a reliable, experimental technique for studying concept formation. In this early experimentation, Hull considered concept formation as a generalizing abstraction—a process that involved the discrimination of a particular element common to a variety of stimuli.

According to Skinner (1953, 1957), any property of a stimulus which is present when a response is reinforced acquires some degree of control over that response. This control is exerted thereafter when the element appears in other combinations. The behavior of an individual may be brought under the control of a single element or a combination of elements of a stimulus while being eliminated from the control of all other properties. In order to achieve this type of control there must be reinforcement of the property that is to be discriminated and subsequently utilized in the abstraction.

Bourne and Restle (1959) attempted to explain concept formation with a mathematical model of learning based on discrimination learning. Conditioning of the relevant cues is an integral part of this explanation.

Harlow (1959) gives discrimination an important place in learning set and considers discrimination as basic to concept formation. In his uniprocess theory, Harlow suggests that learning set consists of a discrimination process and elimination of responses and response tendencies that are inappropriate to the particular learning situation.

The designs of the experiments conducted by the preceding psychologists are good; however, the results appear to have only modest applicability to the learning of concepts in everyday situations. A number of modern psychologists are convinced that there are internal processes that mediate between stimulus and response, between the problem and its solution. Among these are Cofer and Foley (1942), Kendler and D'Amato (1955), Osgood (1957), and Miller and Dollard (1941). Evidence for this point of view is suggested by the fact that the human being makes similar responses to different stimuli; i. e., conceptual responses that are thought to be the results of acquired rather than primary stimulus equivalence. Ericksen (1962) is one of the modern scholars working on one mediating process, namely abstraction.

Newell, Shaw, and Simon (1958) are attempting to explain human thinking from the stimulation of thinking in high speed electronic computers. In this type of research, analogies are drawn between human and mechanical processes. Their model appears to have some applicability to learning by individuals. How much it clarifies human learning processes is unclear.

The most ambitious attempt to explain global processes in concept attainment is that of Bruner, Goodnow, and Austin (1956). Different from most previous experimenters, they presented all the instances of the concepts to be attained simultaneously. The attempts of Bruner, et al. to explain the processes in concept learning resulted in their defining four ideal selection strategies and two ideal reception strategies. However, very little experimental evidence was presented regarding each strategy. For example, two ideal selection strategies were identified on a logical, a priori basis, and then defined in the experiments solely in terms of the number of attributes varied on successive card choices from the focus card. An attempt to replicate the selection strategies of Bruner, et al. is given in a doctoral thesis of Byers (1961) at Wisconsin. The replication proved impossible, and Byers concluded that two sets of the four selection strategies were in fact identical, that there were only two selection strategies.

Despite this sketchy experimental information, Bruner et al. (1956, p. 64) gave a comprehensive definition of the functions of an ideal strategy:

> A strategy refers to a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives, i.e., to insure certain forms of outcome and to insure against certain others. Among the objectives of a strategy are the following:
>
> a. To insure that the concept will be attained after the minimum number of encounters with relevant instances.
> b. To insure that a concept will be attained with certainty, regardless of the number of instances one must test en route to attainment.

c. To minimize the amount of strain on inference and memory capacity while at the same time insuring that a concept will be attained.
d. To minimize the number of wrong categorizations prior to attaining a concept.

This concept of an ideal strategy is provocative but leaves much to be desired concerning how the responses of _S_s should be categorized in order to determine possible differences in the strategies which _S_s actually use in attaining concepts. Many aspects of the pattern of responses, in addition to the number of attributes varied from the focus card and the number of hypotheses possibly eliminated with each successive card choice, should be examined in order to understand the possible differences among various strategies.

Miller, _et al._ (1960, p. 18) designate control of all behavior as _Plan_. Plan, in their theoretical formulation of the structure of behavior, is analogous to program in the electronic computer. They state:

> Any complete description of behavior should be adequate to serve as a set of instructions, that is, it should have the characteristics of a plan that could guide the action described. When we speak of a Plan in these pages, however, the term will refer to a _hierarchy_ of instructions, ... _A Plan is any hierarchical process in the organism that can control the order in which a sequence of operations is to be performed_.

Similarities between the characteristics of strategy and plan are noteworthy. Both strategies and plans are learned by the individual. Both are applicable to a variety of situations encountered by individuals, although plan is more comprehensive. Both affect the order or hierarchy of operations, primarily cognitive, by which the individual deals with his physical and social environment. Both affect the selection, acquisition, recall, and use of information by the individual. As theoretical constructs, both pose explanations that go beyond either S-O-R or Gestalt theory but combine elements of each.

Bruner, et al. proposed that individuals would vary strategies according to situational variables. For example, if considerable time were available, the individual might use a conservative strategy; whereas if little time were available, a gambling strategy would probably be used.

Although strategies may change according to situational variables, it is possible that when the same experimental situation is encountered by different individuals, one strategy may prove more efficient than others. Thus, it is hypothesized that the strategies which individuals and groups use in attaining concepts are related to the efficiency of attaining concepts. Groups were included in the hypothesis because of the frequency with which group work is pursued in the schools. Information concerning groups will be presented in connection with the fourth hypothesis.

b. The strategy used by an individual and by a group changes with the type and meaningfulness of the material in which the concepts are embedded—figural of low meaningfulness, semantic of low meaningfulness, and semantic of high meaningfulness.

There are many stimulus variables which affect efficiency of the learning of concepts (Kendler, 1961). One of the most accessible of these is the type of material in which the concepts are embedded. Heidbreder (1946, 1949) reported that concepts were attained with varying degrees of efficiency, depending upon the type of stimulus material in which the concepts were embedded. Grant and Curran (1949) did not attain the same results. However, the difference in results probably appeared because of the different experimental procedures that were used by the different investigators (Wolhill, 1957). In the present study, in order to test this hypothesis, the same experimental procedures were used with three different types of stimulus material.

c. Type of instructions and knowledge of a principle affect efficiency of attaining concepts.

In schools and in the laboratories, students are given instructions concerning many learning tasks. In general, it is assumed that the instructions are helpful to the Ss. Instructions sometimes incorporate information about a principle which supposedly will facilitate acquisition of the task. Some research has been done related to instructions in general and some related to a principle; relatively little has been done in connection with concept attainment.

Craig (1956), Kittell (1957), and Haselrud and Meyers (1958) reported that giving Ss information about a principle facilitated learning. This is in agreement with earlier research. In the present study, the effects of a principle upon efficiency of concept attainment were determined. Also, its effect in combination with various instructions was ascertained.

Research regarding the effects of instructions are unclear, probably because instructions are somewhat unique to the situation and adequate standardization has not been done to make meaningful comparisons. It is possible, however, that one or more efficient strategies of learning can be found and that these strategies can be incorporated in instructions to naive subjects. (If efficient strategies could be found for learning in the various subject fields and subsequently incorporated into workable instructions, the results on school learning would be considerable.)

French (1954) studied the effect of instructions in a complex rational learning task involving the discovery of a correct sequence of switch manipulation. Instructions improved performance. Underwood and Richardson (1956) reported the effects of dominance level and instructions on the learning of verbal concepts. They found that, as dominance level increased and as amount of instruction given to the S increased, performance improved. Archer, Bourne, and Brown (1955) found no significant effect for instructions in a concept identification task. Apparently, the experimental arrangements determine the effects of instructions. In the present study, the effects of three types of instructions, one of which incorporated a strategy, were determined.

d. Attaining concepts initially as a member of a group, in comparison with attaining them as an individual, results in lower efficiency when attaining subsequent concepts individually.

How efficiently persons attain concepts when working as individuals and as members of groups is of significance in schools as well as in other settings. According to Lorge, Fox, Davitz, and Brenner (1958), the considerable experimentation on the quality of group and of individual performance has not yet produced conclusive results. In his survey of problem solving, Duncan (1959) concluded that the more efficient individuals usually perform better than the mean performance of the groups. Anderson

(1961) found that groups of three achieved higher than groups of two, and groups of two higher than individuals. In none of these reports was information presented concerning the effects of initial group work on subsequent performance as an individual. Until very recently, researchers have been satisfied to stop with initial learning and have not determined the effects upon subsequent performance. In the present study it was possible to determine the effects of groups on initial and upon subsequent performance.

e. Sex, age, general intellectual ability, divergent thinking abilities, values, and major field of study are related to strategies used and to efficiency in attaining significant concepts in educational psychology.

In recent concept attainment studies that use stimulus material of the type in this study, attention has not been given to the characteristics of the Ss. It is assumed, apparently, that there is generalizability of results, regardless of the characteristics of the Ss. While it may be appropriate not to ascertain characteristics of the Ss in most studies, it seemed essential to do so in this study because organismic factors might be operating and confounding the results regarding strategies.

No review of the vast literature is necessary to indicate the importance of the above variables in connection with most outcomes of learning. Kendler (1961) reported only studies dealing with two of the above variables—age and mental age. As children grow older they attain concepts more efficiently and as mental age increases concepts are attained more efficiently. In the present study the Ss were above the CA discussed by Kendler and also, it was impractical to attempt to ascertain their mental age.

PRIOR EXPERIMENTS AT THE UNIVERSITY OF WISCONSIN

In the first semester, 1959-60, experimental materials were developed. Support for the early experimentation, which continued through the academic year 1961-62, was provided by the Research Committee of the Graduate School of the University of Wisconsin.

As may be inferred from the preceding discussion, the work of Bruner and his associates (1956) provided the model for the first experiments. The principal knowledge about strategies in concept attainment derived from Bruner's work is summarized briefly.

1. Experimentation on strategies in concept attainment was almost non-existent prior to 1951; an appropriate design had not been devised for this type of experimentation.

2. Four ideal strategies were identified on _a priori_ grounds—simultaneous scanning, successive scanning, conservative focusing, and focus gambling. An individual's actual performance in an experiment was judged by Bruner _et al_. to correspond more closely to one or another of the four ideal strategies.

3. The effects of relevant conditions upon each of the strategies were ascertained, thus assuring the researchers that they were describing

the process of concept attainment rather than evaluating whether or not the subjects had succeeded or failed in attaining concepts.

4. Strategies that individuals use were found to be dependent upon a variety of organismic and situational variables.

At the outset in the Wisconsin experiments, the subjects' performances could not be matched to Bruner's four ideal strategies. Further, Byers (1961) demonstrated that the four ideal strategies could be placed on a single continuum of conservative focusing-focus gambling. Therefore, Bruner's ideal strategies were abandoned in favor of time-to-criterion to ascertain the relative efficiency of various strategies. The principal results from the early experiments were these:

1. Experimental material of an appropriate level of difficulty for younger and older Ss was devised.

2. A replicable system of strategy identification was formulated. However, the identification system, based on mathematical probabilities as reported by Byers (1961), was abandoned in favor of a more psychologically meaningful system which will be described later.

3. Efficiency of performance was not related to the strategy employed by the S, using the strategy identification procedures of Byers.

4. Older Ss, above age 26, performed significantly less efficiently than younger Ss, age 20-25.

5. Significant improvement in efficiency of performance across trials occurred for both older and younger Ss.

Though the system of strategy identification was changed, recognition is given to Professor Joe Byers, now at the University of California, and Professor E. James Archer, University of Wisconsin, for developing the first experimental materials. Further, it was necessary to test out the first system of strategy identification in order to find those of Bruner *et al*. unsatisfactory and to devise the more psychologically meaningful system, which is explained in the first experiment.

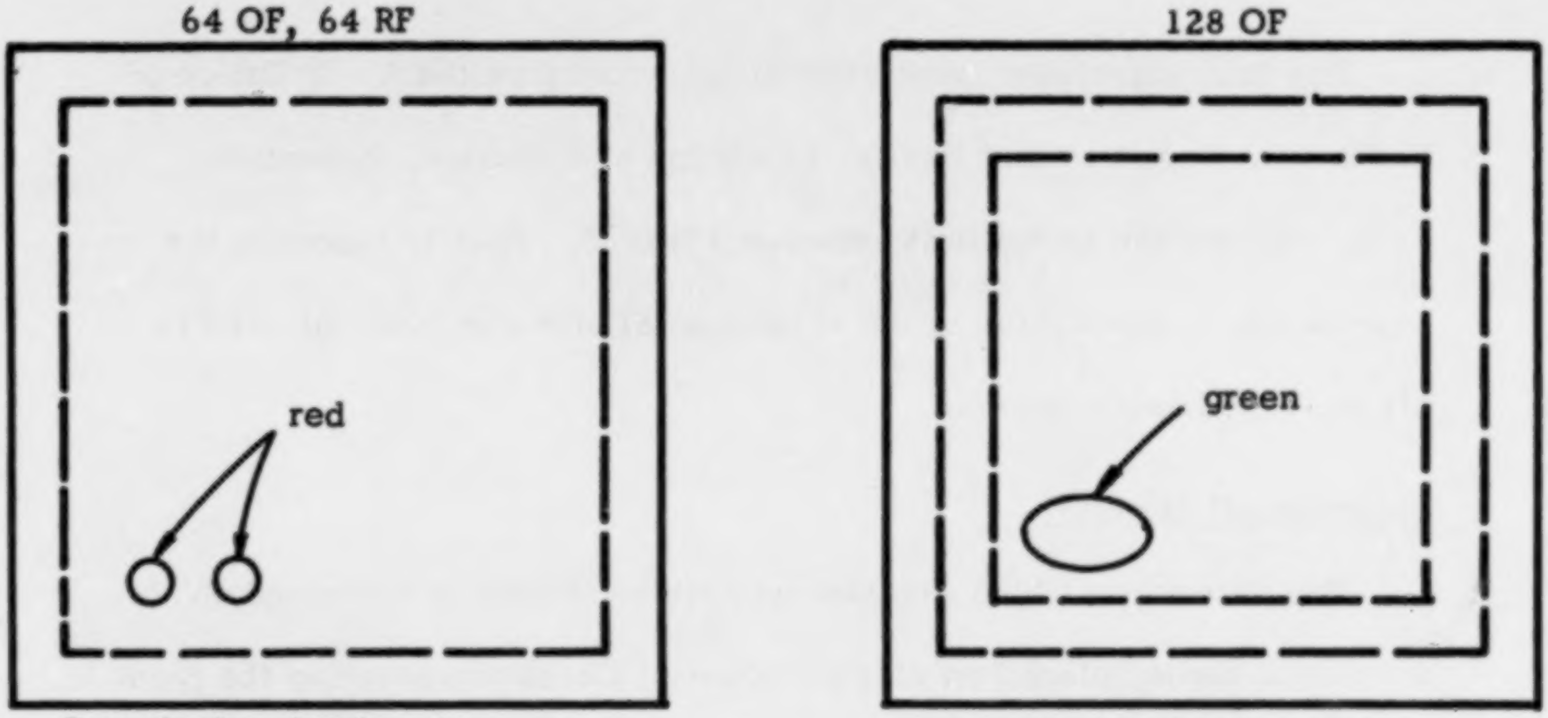
EXPERIMENT 1: EFFICIENCY OF STRATEGIES IN CONCEPT ATTAINMENT AND STRATEGY USAGE ACCORDING TO TYPE OF STIMULUS MATERIAL FOR YOUNGER SUBJECTS

The first experiment conducted with support from the U. S. Office of Education, Department of Health, Education and Welfare, Project No. 1442, was started in the first semester 1961-62. Prior to reporting the experiment, a description of the experimental stimulus material used in all the experiments is given.

Experimental Material

The material in which the concepts are embedded is contained on 3 × 3 inch cards, placed on display boards. Cards representing the type of stimulus material used are shown in Figure 1. Each board includes a collection of discriminable, different information on each card but the information on each card can be used to define any of a large number of possible concepts. This is clarified in the discussion of the display boards, the first five of which were developed prior to starting Project 1442.

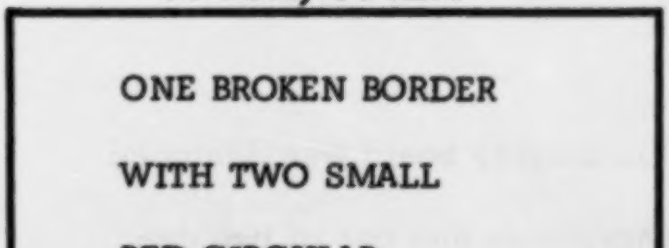
128-Card Ordered Figural (128 OF). This display board was designed by making each card contain each of seven attributes and one of two defining characteristics, or values, the total display incorporating the



One—broken border—two small—red—circular figures

two—broken borders—one large—green—ellipse

64 OLM, 64 RLM


ONE BROKEN BORDER
WITH TWO SMALL
RED CIRCULAR
FIGURES

64 OHM

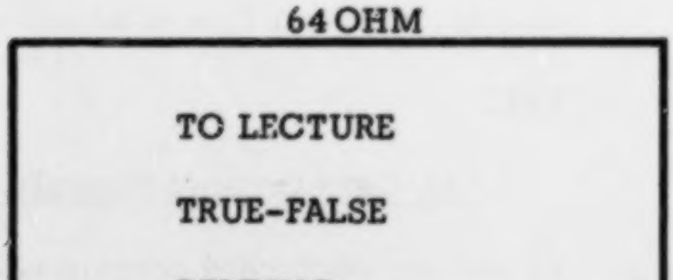

TO LECTURE
TRUE-FALSE
READING
TRIGONOMETRY

Fig. 1. Sample Cards from the Six Boards used in the Experimentation.

attributes and defining characteristics in all possible combinations thus:

7 Attributes	Defining Characteristics
Number of Borders	one or two
Continuity of Borders	solid or broken
Number of Figures	one or two
Size of Figures	small or large
Texture of Figures	solid or spotted
Color of Figures	red or green
Shape of Figures	circle or ellipse

One hundred twenty-eight concepts embedded on this display board can be defined by the information on each card separately, e.g., one solid border with one small solid red circle, two broken borders with two large spotted green ellipses. One single concept can be defined by the information on all 128 cards—one or two, broken or solid borders with one or two, small or large, solid or spotted, red or green, circles or ellipses. A large number, 2186, concepts can be defined by combining one or more of the seven attributes with one or two of the defining characteristics. Eighty-four concepts of two relevant attributes in combination with one or more defining characteristics; e.g., broken borders—circular figures, two borders—small figures, solid—red figures, one—large figure, are contained on the 128-card board, and for each there are 32 positive instances or exemplars and 96 negative instances. Stated differently, each concept of two relevant attributes serves to categorize all 128 cards into two groups, one group of 32 exemplars of the concept and another group of 96 non-exemplars. The 96 non-exemplars could be used, of course, to define another concept of five relevant attributes.

The 128 cards have been placed on the board in an ordered array of 8 rows and 16 columns.

64-Card Ordered, Figural (64 OF), 64-Card Random Figural, (64 RF), 64-Card Ordered Low Meaningfulness, (64 OLM), 64-Card Random Low Meaningfulness, (64 RLM). Two of the 64-card boards are figural with cards identical to the 128-card board except for the omission of the 64 cards containing spotted figures. One board presents an ordered arrangement, the other a random arrangement. Closely related to these two boards are two low-meaningfulness semantic boards. These boards display attributes and defining characteristics identical to the 64-card figural boards, but the attributes and defining characteristics are stated in words.

64-Card Ordered High-Meaningfulness Semantic Board (64 OHM). This 64-card board has words on each card, drawn primarily from the content of educational psychology. The entire set of cards presents two attributes with two defining characteristics each, and two attributes with four defining characteristics each in all possible combinations:

4 Attributes	Defining Characteristics
Teacher Method	classroom management, presenting information
Pupil-Teacher Interaction	motivation or evaluation
Learning Outcome	facts, motor skills, attitudes, verbal skills
Subject Field	foreign language, mathematics, science, social studies

Each card on this board requires an inference to arrive at the defining characteristic. For example, on one 3 × 3 card, the following words are entered and the inference must be made as follows:

Card Information	Inference
To Lecture	presenting information
True-False	evaluation
Reading	verbal skill
Trigonometry	mathematics

The 64 cards are presented in an ordered array on the board.

81-Card Ordered High-Meaningfulness Semantic Board (81 OHM). The 81 OHM has words on each card, drawn primarily from the content of educational psychology. The entire set of cards presents four attributes with three defining characteristics each, in all possible combinations thus:

Four Attributes	Defining Characteristics
Teacher Method	motivation, evaluation, presentation
Learning Outcome	fact, attitude, motor skill
Grade Level	elementary, secondary, college
Subject Field	mathematics, science, social studies

Each card on the board requires an inference to arrive at the defining characteristic. For example, on one 3 × 3 card, the following words are entered and the inference must be made as follows:

Card Information	Inference
Encourages	motivation
To Jump	motor skill
1st Grade	elementary school
Arithmetic	mathematics

A small card indicating the four attributes was made in order to reduce the memory strain of the Ss. The cards have been placed on the board in an ordered array.

27-Card Ordered High-Meaningfulness Board (27 OHM). This board is the same as the 81 OHM except that the attribute, grade level, is eliminated.

Purposes

The purposes of the first experiment were:

1. To ascertain the applicability of a system of strategy identification to concepts embedded in three kinds of stimulus material.

2. To determine the extent to which the strategies used by individuals are related to the efficiency of attaining the concepts.

3. To determine the extent to which the strategies used by individuals are related to the type and meaningfulness of the material in which the concepts are embedded—figural of low meaningfulness, semantic of low meaningfulness, and semantic of high meaningfulness.

4. To determine the effects of sex, problem, sequence, and ordinal position on the efficiency of attaining concepts.

Subjects

The Ss were 32 males and 48 females drawn from three classes of educational psychology. The age range of the 80 Ss was from 20 to 25; the modal age was 21. A block of 8 females and 8 males were the Ss for each of the three types of stimulus material—random figural, random low meaningful semantic, and ordered high meaningful semantic. A partial replication using the verbal random low meaningful semantic material and the ordered high meaningful semantic material was done with a block of 8 females and 8 males and a complete block of 16 females, respectively. The larger number of females was used because of ready availability; analysis of the results from the first group of 24 females and 24 males revealed no statistically significant sex difference.

The 64 RF, 64 RLM, and 64 OHM, as described previously, were used. One block of 16 subjects used the 64 RF, two blocks of 16 subjects each used the 64 RLM, and two blocks of 16 subjects used the 64 OHM.

The four concepts to be attained on the 64 RF and 64 RLM were identical, as follows: two borders—green figures, broken borders—ellipses, two figures—circles, and small figures—red. Each of these concepts has two relevant attributes, and on each board there are 16 positive and 48 negative instances of each concept. Previous experience with these concepts indicated that they were of about the same difficulty to attain. The four concepts to be attained on the 64 OHM were: classroom management—language skills, teacher presentation—mathematics, evaluation—foreign language, and motivation—facts. Previous experience with these concepts also indicated that they were of about equal difficulty.

Experimental Procedure

Each S reported to the Learning Laboratory and received instructions. The specific instructions for the 64 RF and 64 RLM were identical and follow immediately; the slight change in the instructions for the 64 OHM was then given.

INSTRUCTIONS FOR RANDOM FIGURAL AND RANDOM VERBAL LOW-MEANINGFULNESS BOARDS

"This experiment is concerned with how people attain concepts. You are going to have an opportunity to work several exercises in concept attainment. Your performance on this is not related to your course grade.

"Here is a display of 64 cards. Each card contains six attributes. The attributes are number of borders, type of borders, number of figures, size of figures, color of figures, and shape of figures. Each card has either one or two borders, broken or solid borders, one or two figures, large or small figures, red or green figures, and circular or elliptical figures. (E demonstrates with slip of paper which has the attributes listed in one column and the defining characteristics in another column.)

"Every card on the board is different from every other card in at least one of the six attributes just described. However, there are a number of ways certain cards may be grouped so that all cards in a specific group possesses one or more of the same attributes. To illustrate from the animal kingdom, we know that all animals can be classified into two distinct groups—vertebrate and invertebrate. Thus every animal either does or does not have a backbone and may be put into either group—vertebrate or invertebrate. In a like manner, all the cards indicative of 'Green Circles' may be grouped together to form the concept 'Green Circles.' Here are two of several cards which belong to this concept. (E points to #72 and #35) You pick out three others which also belong to the 'Green Circles' concept. (Wait for S to pick out such cards). Now pick out two cards which do not belong to this concept. (Wait for S to pick two such cards). O.K., that's fine. This is an example of a concept that has two relevant attributes, the two relevant attributes being color and shape of figures. (E in putting down this concept puts checks on slip—(X) green and (X) circle on slip.) In this experiment your job is to attain the concept that I have selected.

At the beginning of each task I shall show you one card which belongs to a concept that I have selected and which you are to attain. This card we shall call the focus card. You are to select cards which you want to test as belonging to the same concept as the focus card. Select each of your successive cards by pointing to it and reading off the number which is immediately below it. After each selection I shall state 'yes' or 'no' depending upon whether or not the card you selected belongs to the concept. As you find which cards do and do not belong to the concept you can ascertain the concept. Whenever you think you know the concept, stop and ask for a slip of paper. Then check the concept on the slip and I shall read the concept back to you so there is no misunderstanding. If your concept is correct the task is completed. If not, I'll simply say 'not correct' and you will continue selecting cards until you again think you know the concept. You may present as many concepts as you like. The job is to attain the correct concept as quickly as possible. Are there any questions?

INSTRUCTIONS FOR ORDERED HIGH-MEANINGFULNESS BOARD

"This experiment is concerned with how people attain concepts. You are going to work several problems in concept attainment. Your performance in this experiment is not related to your course grade."

"Here is a display of 64 cards. Each card contains four attributes. The top line (E demonstrate throughout with large card) on each card represents an instance of teacher method, the second line an instance of pupil-teacher interaction, the third line a learning outcome and the fourth line a subject area. The top line always represents one of two teacher methods —classroom management or presenting information; the second line one of two pupil-teacher interactions—motivation or evaluation; the third line one of four learning outcomes—facts, motor skills, attitudes, or language skills; the fourth line one of four subject areas—mathematics, social studies, science or foreign language."

"Every card on this board is different from every other card in at least one of the four attributes just described. However, there are a number of ways certain cards may be grouped so that all the cards in a specific group possess one or more of the same attributes. As an example, all of the cards indicative of 'Evaluation—Social Studies' may be grouped together to form the concept 'Evaluation—Social Studies.' Here is one of several cards which belongs to this concept (E points to #78.) You pick out two cards which do not belong to this concept. (Wait for S to pick two such cards.) O.K., that's fine. We mark this concept in the following manner on this slip. (E introduces slip and illustrates its uses.) The concept just discussed is what we call a concept with two relevant attributes, the two relevant attributes being pupil-teacher interaction and subject area."

"In this experiment your job is to attain the concept that I have selected. At the beginning of each task I shall show you one card which belongs to a concept that I have selected and which you are to attain. This card we shall call the focus card. You are to select cards which you want to test as belonging to the same concept as the focus card. Select each of your successive cards by pointing to it and reading off the number which is at the bottom of the card. After each selection I shall state 'yes' or 'no' depending upon whether or not the card you selected belongs to the concept. As you find which cards do and do not belong to the concept, you can ascertain the concept. Whenever you think you know the concept, stop and ask for a slip of paper. Then check the concept on the slip and I shall read the concept back to you so there is no misunderstanding. If your concept is correct the task is completed. If not, I'll simply say 'not correct' and you will continue selecting cards until you again think you know the concept. You may present as many concepts as you like and pick as many cards as you like. The job is to attain the correct concept as quickly as possible. Are there any questions?"

Each S was given the same four concepts to attain on the respective boards but in four different sequences. In order to control possible differences in difficulty among the concepts and the order and sequence in which the Ss encountered the concepts, a Latin Square was used in assigning sequences to Ss. Each S, drawn randomly from the larger population, appeared at the Learning Laboratory and was assigned one of the sequences. In the block of 16, where the N of males and females was equal, each sequence was used four times for males and four times for females.

The entire concept attainment task, consisting of attaining four concepts in sequence, was performed in one class period of 50 minutes or less. To accomplish this, a S who did not attain the first concept in 20 minutes or less and the second concept in 15 minutes or less was dismissed and replaced. Five Ss were dismissed because they did not meet the time criteria of 20 and 15 minutes, respectively.

Results

The results connected with procedures for identifying strategies are given first, and then the substantive results from further analysis of the data are presented.

Procedures for Identifying Strategies

After Ss had completed the task, identification of the strategy the S used when attaining a concept was made on two main bases. First, the first hypothesis offered by the S was checked to ascertain whether it was the correct concept. Each hypothesis offered by S was his statement of what he thought the concept was. Second, all the card choices made by S prior to his stating a first hypothesis were examined. The E determined the number of attributes varied on each successive card choice from previous choices and the focus card, and also determined which attributes were varied. From this analysis, the amount of new information each successive card choice yielded potentially was ascertained. If a card choice yielded information already acquired potentially by the S it was classified as a redundant choice.

On the basis of this analysis, the strategy was designated as one of three variants of a conservative strategy—Ca, Cb, and Cc—or as one of two variants of a gambling strategy—Gh and Gi. The description of the strategies which follows shows that a strategy is not the criteria for identifying it. The strategy is the cognitive control within the organism that determines his selection of instances for testing, processing of information, and inferring. Table 1 summarizes the observable criterion behavior for classifying the five strategies and also the strategy characteristics.

1. Conservative Strategy (Ca). When using Ca, the S checked each attribute and thus had all of the necessary potential information to attain the concept; he offered a first hypothesis which was the correct concept and thus acquired all the essential information; and he made redundant choices below the median number made by all Ss using Ca and Cb strategies. These three facts relative to the S's performance can be objectively determined by an inspection of the data. From these facts it can be

Table 1

Summary of the Strategy Identification System and the Characteristics of Strategies

Designation	Observable Criterion Behavior	Inferences Based on Knowledge of Observable Behavior
Conservative a	Tested all attributes. Offered 1st hypothesis which was correct. Made below median number of redundant card choices.	Selected essential information. Cognized potential information. Remembered essential information. Made correct inferences.
Conservative b	Tested all attributes. Offered 1st hypothesis which was correct. Made above median number of redundant card choices.	Same as Ca, except in relation to above-median number of redundant choices. Intentionally retested more attributes, or did not cognize potentially available information, or remembered information less well.
Conservative c	Tested all attributes. Offered 1st hypothesis which was incorrect.	Did not cognize potential information, or did not remember it, or made incorrect inferences.
Gambling h	Did not test all attributes. Offered 1st hypothesis which was correct.	Gambled successfully about nature of concept. Identified relevant attributes through any of 3 types of card choices. Selected essential information for relevant attributes. Cognized potential information. Remembered essential information. Made correct inferences.
Gambling i	Did not test all attributes. Offered 1st hypothesis which was incorrect.	Gambled unsuccessfully about nature of concept, or gambled successfully on nature of concept but did not select, cognize, or remember information, or did not draw correct inferences.

inferred further that the S selected the essential information from that available, cognized the essential information, remembered the information, and made the inferences necessary to hypothesize the correct concept.

2. Conservative Strategy (Cb). The criteria for identifying Cb are the same as Ca, except that the number of redundant choices is above the median. The inferences drawn about Cb are the same as for Ca, with additional inferences based on the above-median redundancy. When using this strategy, S intentionally retested more of the same card or cards containing equivalent information, or remembered information less well and thereby retested the same attributes, or did not cognize the potentially available information from earlier card choices.

3. Conservative Strategy (Cc). When using Cc, the S tested each attribute, thus having all the necessary information potentially but, after doing so, offered an incorrect hypothesis. It can be inferred that the incorrect hypothesis resulted from one or a combination of the following: the S made the card choices essential for securing the necessary information but did not cognize part of it, or forgot part of it, or made an incorrect inference relative to the concept.

4. Gambling Strategy (Gh). When using Gh, the S offered a first hypothesis which was the correct concept, without having checked all the attributes. In order to accomplish this, the S gambled correctly that the concept was defined by two relevant attributes. He was then able to identify the concept through any of three patterns of card choices:

first, selecting "yes" cards which contained the two attributes that defined the concept; second, selecting certain "no" cards from which the two attributes that defined the concept could be inferred directly; and third, selecting some combination of "yes" and "no" cards which defined the concept but did not provide information about all the attributes. In addition, it may be inferred that the S, when using Gh, actually cognized the potential information from his card choices, remembered it, and drew the correct inferences from it.

5. Gambling Strategy (Gi). When using Gi, the S offered a first hypothesis which was incorrect without having checked all the attributes. In contrast to an S using the Gh strategy, he did not gamble correctly that the concept was of two relevant attributes; or, if he did so, he did not cognize the potential information, or did not remember it, or did not draw the correct inferences.

These five strategies are not ideal. They were not arrived at on an a priori basis as were those defined by Bruner et al. (1956). Instead, they are explanations of processes, based on examination and study of many sets of responses of Ss who were not instructed about strategy or the nature of the concepts embedded in the various types of material. The strategy employed by a S in attaining any concept was determined objectively, without recourse to instructing him or securing information from him, other than his card choices. Experimenters familiar with the system independently classified performances of Ss with 100 percent agreement as to the strategy used.

This system of strategy identification proved satisfactory for classifying the Ss' responses pertaining to the concepts embedded in the three different types of stimulus material. Other substantive results are now presented:

1. Table 2 gives the mean time in minutes to attain a concept according to display board and strategy. As may be observed in Table 2, Gh was most efficient for three of five groups of Ss and second most efficient for two of five; Ca was most efficient for two groups and second most efficient for three; Cb was third most efficient for three of four and fourth most efficient for one; strategy Gi was second least efficient for four of five groups and least efficient for one; and Cc was least efficient for four groups and second least efficient for one. In general, the efficiency of strategies is in the same order as presented in Table 2: Gh, Ca, Cb, Gi, and Cc; a sharp break occurs between strategy Ca and Cb, and also between Cb and Gi. Since the various strategies were used an unequal number of times, no test of significance for strategy was computed in the Latin-Square ANOVA.

Table 2

Mean Time in Minutes to Attain a Concept in Each of Four Positions of a Sequence According to Type of Stimulus Material and Strategy

Board	Strategy					
	N	Gh	Ca	Cb	Gi	Cc
64 RF	16	1.48	1.25	**	4.75	5.75
64 RLM	16	2.07	3.76	4.09	8.92	8.16
64 OHM	16	1.94	3.72	6.04	6.49	6.83
64 RLM*	16	2.54	2.51	2.80	7.06	6.14
64 OHM*	16	1.51	2.42	5.97	5.91	12.90

[*] Replication Group

[**] No S used Cb strategy on this board

In Table 3 are presented the results of one-way ANOVAs for the five groups. Each ANOVA shows the difference among strategies to be significant at or beyond the ..05 level. Thus, regardless of the type of stimulus display in which the concepts were embedded, and for the replication as other groups, efficiency of performance was significantly related to the strategy employed.

Table 3

Mean Squares and F-Ratios from One-Way ANOVA's for Efficiency of Strategies by Type of Stimulus Material

Source	df	MS	F	P
RF	3	38.32	4.04	.05
RLM	4	120.60	7.68	.01
OHM	4	54.71	2.92	.05
RLM*	4	68.51	6.71	.01
OVM*	4	196.87	13.10	.01

*Replication group.

2. The incidence of strategies according to boards is shown in Table 4. The most frequently used strategy on all boards by all groups

Table 4

Incidence of Strategies for Three Types of Stimulus Material

Board	Strategy				
	Gh	Ca	Cb	Gi	Cc
RF	10	1	0	45	8
RLM	9	9	8	28	10
OHM	13	3	4	43	1
RLM*	8	6	9	34	7
OHM*	17	3	2	33	9

*Replication groups.

was Gi; generally Gh was second, then Cc, Ca, and Cb. The high incidence of Gi and Gh strategies on all boards suggests the strong tendency for the Ss to state an hypothesis prior to having tested all the relevant attributes.

Chi-square tests were run on the incidences of the strategies on the various boards and these values are given in Table 5. The distributions of the five strategies by boards differ significantly as the stimulus material changes. For all trials on the 64 OHM, 64 RLM, and 64 RF, a χ-square was significant at the .01 level (x^2 = 28.42, d.f. = 8). The incidence between the initial experiments and the replication was not significant for either the OHM or the RLM material; and the difference among the RF and the initial and replicated OHM and RLM combined was significant. As may be observed in Table 4, the conservative strategies were used less and the gambling strategies more on the RF, in comparison with the other boards.

Table 5

Results of Chi-square Tests of Strategy Distributions for Three Types of Stimulus Material

Boards Compared	X^2-value	df	Significance
RF-RLM-OHM	28.42	8	.01
RLM-RLM*	1.82	4	NS
OHM-OHM*	8.90	4	NS
RF-RLM*-OHM*	29.82	8	.01

3. Table 6 shows the effects of sex, sequence of problems, problems, and ordinal position. As indicated by the F-ratios, males and females did not differ significantly in time-to-criterion; sequence of concepts to be

attained was significant between the .05 and .01 level for only the RF; at least one problem was more difficult than another at the .01 level, on the OHM for both the original and the replication group, but not on the other boards, and the ordinal position was highly significant for all groups except on the RF.

Table 6

Mean Squares and F-ratios of the Effects of Sex, Sequence, Problem, and Ordinal Position

Board	Sex		Sequence		Problem		Ordinal position	
	MS	F	MS	F	MS	F	MS	F
RF	4.00	<1.0	45.47	4.29+	6.27	1.28	9.46	1.93
RLM	0.61	<1.0	36.21	1.18	1.44	1.0	106.36	25.75**
OHM	7.90	<1.0	6.97	1.0	59.89	4.64**	60.55	4.69**
RLM*	not applicable		44.14	1.0	27.25	3.04+	40.46	4.52**
OHM*	0.00	<1.0	10.78	1.0	119.49	6.37**	94.94	5.06**

*Replication groups

**Significant at .01 level or beyond

+Significant between .05 and .01

Figure 2 shows the ordinal position effect for the three boards, with this effect being significant on the 64 RLM and 64 OHM. Improvement across trials was greatest on 64 RLM, next on 64 OHM, and least on 64 RF. The amount of improvement was closely related to time-to-criterion on Trial 1. In other experiments performance improved across trials in about the same pattern as shown in Figure 2, except that it also improved in Trial 4 for the figural boards.

Sequence was also significant on the 64 RF. The mean times in minutes for the sequences on the RF were: sequence I, 5.89; sequence II, 3.05; sequence III, 5.63; and sequence IV, 2.66. No explanation of the difference according to sequence can be offered.

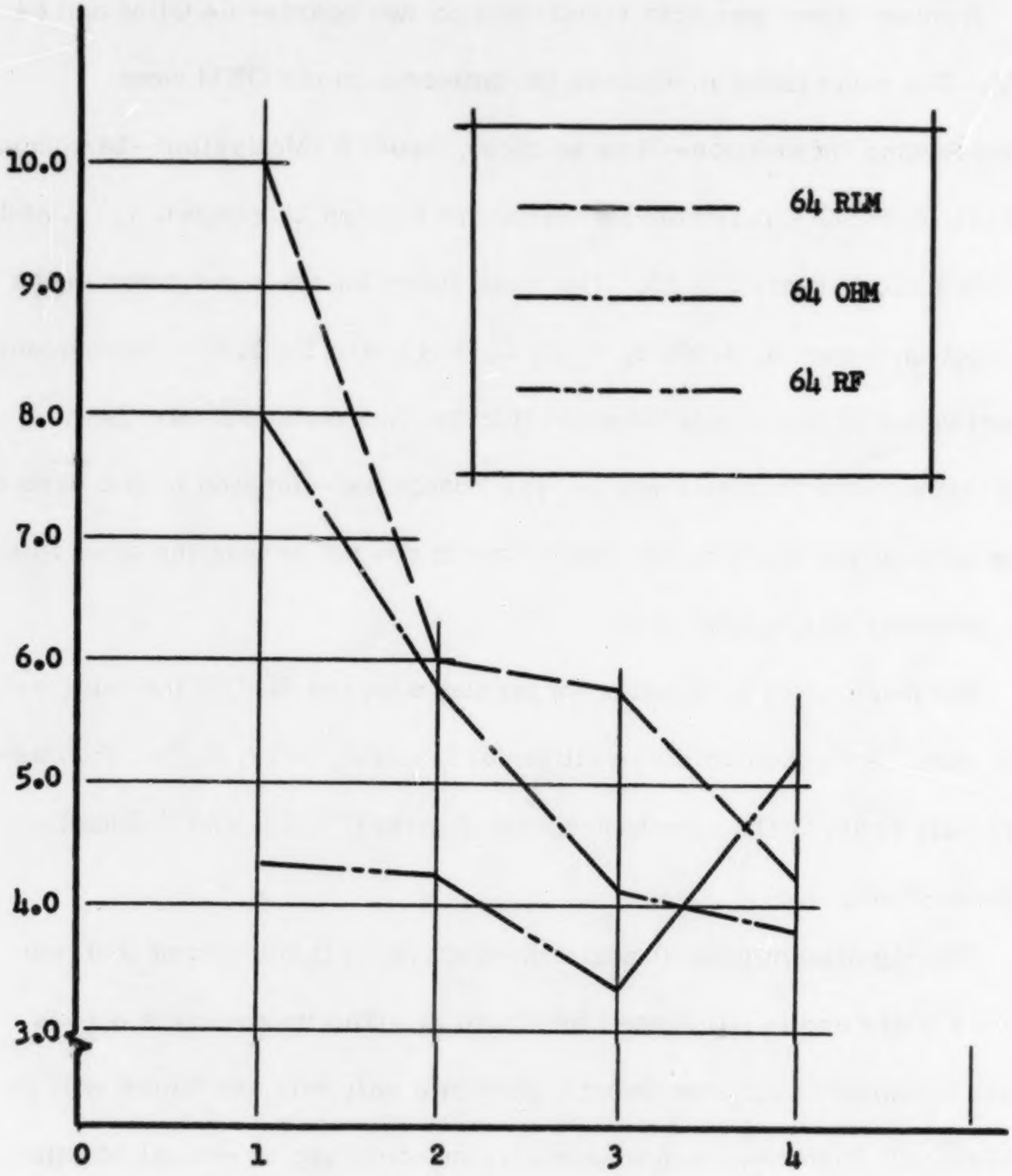


Fig. 2. Mean Time in Minutes to Attain Four Concepts Embedded in Three Types of Stimulus Material.

Problem effect was also significant on two boards—64 OHM and 64 RLM. The mean times in minutes for problems on the OHM were: A (Presenting Information—Mathematics), 3.08; B (Motivation—Language Skills), 4.58; C (Classroom Management—Foreign Language), 7.15; and D (Evaluation—Facts), 6.85. The mean times for the same board in the replication were: A, 3.67; B, 3.60; C, 9.43; and D, 5.55. Subsequent examination of the boards revealed that the two problems with the high total times were problems whose "yes" cards were located in two separate quadrants of the board rather than a row or column as was the case with the problems of low total time.

The mean times in minutes for problems on the RLM in the replication were: A (Broken Borders—Elliptical Figures), 5.77; B (Two Figures—Circles), 6.80; C (Two Borders—Green Figures), 5.25; and D (Small Figures—Red), 3.67.

The significant ordinal position effect is an indication of learning across trials and is illustrated by Figure 2. (The improvement across trials occurred in all experiments; therefore only this one figure will be presented.) Improvement across trials, or according to ordinal position, was not significant on the 64 RF because the time-to-criterion was quite low on the first trial and, on the fourth trial, it was considerably higher than on the third trial, as shown in Figure 2. Apparently the S̲s using this board tried to change their methods to improve performance between Trials 3 and 4 but were unsuccessful. The concepts embedded in the figural material, wherein the attributes were easily observed, were much

easier to attain in the early trials than were the concepts embedded in words. The words on the 64 RHM and 64 OHM had to be read and understood before relationships among them could be observed; the relationships among the colors and shapes on the 64 RF could be observed directly. With experience, the Ss apparently could recall the position of cards on the 64 RLM and 64 OHM.

EXPERIMENT 2: STRATEGY USAGE BY GROUPS ACCORDING TO THREE TYPES OF STIMULUS MATERIAL

This experiment was conducted during the second semester, 1963-64. As noted in Experiment 1, the efficiency of strategies by individuals according to the type of stimulus displayed was significant.

Purpose

The purpose of this experiment was to determine whether the strategies used by groups changed according to type of stimulus displayed.

Subjects

The _S_s were 96 students drawn randomly from three classes in educational psychology. Seventy-two females and 24 males were distributed according to each type of treatment, with 24 females and 8 males assigned to each treatment. All of the _S_s were in the age range 19-26. The median and modal age was 21.

Experimental Material

Stimulus material on three types of boards was used as in Experiment 1: 64 RF, 64 RLM, and 64 OHM. The concepts to be attained had two attributes in combination with one or more defining characteristics. The four concepts to be attained on the 64 RF and the 64 RLM were: 2 borders—

green figures, broken borders—elliptical figures, two—circles, small—red figures. The four concepts to be attained on the 64 OHM were: evaluation—foreign language, presenting information—mathematics, classroom management—language skills, motivation—facts. These concepts were identical to those attained by individuals in Experiment 1.

Experimental Procedure

A pool of Ss was identified and their available times were noted. These individuals then were combined into pairs with an equal number of males and females and randomly assigned to each of the three treatments or boards. Further random assignment of pairs to each of four sequences for each board was carried out. Each pair reported to the Learning Laboratory and received the identical instructions that the individuals had received as given in Experiment 1.

In addition to the instructions as noted previously, these additional instructions were given: "You are not to compete with each other; you are to work as a team." No other information was given concerning leadership or any other matter connected with the performance of the pair. The card choices made by each pair in attaining a concept were analyzed according to the procedure previously described for identifying the strategy used in attaining the concept.

Results

The incidence of strategies according to type of stimulus material and the results of Chi-square tests on frequency of strategy usage are given in Table 7. Also the results of Chi-square tests for each pair of two boards is given.

As shown in Table 7, the differences in frequency of strategy among boards and between boards were not significant. This is different from the results for individuals where the difference in frequency among the three boards was significant at the .01 level, and also the difference between the RLM and OHM was significant at the .01 level.

A comparison of the incidence of strategy usage according to stimulus boards for individuals (Table 5) and for pairs (Table 7) shows that the pairs used the conservative strategies more frequently for all boards and the Gi strategy less frequently for all boards than did the individuals. Further, the pairs used the five strategies in more nearly equal proportions on all boards than did the individuals.

Table 7

Frequency of Strategy Usage and Chi-square Values* for Pairs, According to Type of Stimulus Material

	Strategy				
Board	Gh	Gi	Ca	Cb	Cc
RF	10	28	12	7	7
RLM	5	36	9	6	8
OHM	10	29	11	7	7

*Chi-square among RF, RLM, and OHM = 3.851, not significant at .05 level
Chi-square between RF and RLM = 2.638, not significant at .05 level
Chi-square between OHM and RLM = 2.764, not significant at .05 level

EXPERIMENT 3: EFFICIENCY OF INITIAL LEARNING AND TRANSFER BY INDIVIDUALS, PAIRS, AND QUADS

This experiment was conducted during the second semester, 1961-1962, and the Ss were of the younger group.

Purposes

In this experiment, the purposes were:

(1) To ascertain whether the Ss acquired concepts equally efficiently when initially working as individuals, in pairs, and in groups of four.

(2) To ascertain whether they performed equally well on an immediate and a delay transfer problem when working as individuals.

Subjects

The Ss were 128 students drawn randomly from classes in educational psychology in two blocks of 64 during two semesters. They were told that participation in the experiment was a requirement of the course and that the main results would be reported back to them toward the end of the semester. All the Ss were in the age range of 21-25; the median and modal age was 21.

Experimental Material

The 128-OF board was used. The four concepts to be attained in the initial learning situation by each individual, pair, and quad were as follows: broken borders—circular figures; two borders—small figures; solid—red figures; and one—large figure. The concept used in the transfer problem was one border—elliptical figures.

Experimental Procedure

Table 8 shows the design of the experiment. Assignment to the three treatment groups was random. Thirty-two Ss participated as individuals in the initial learning situation; subsequently 16 of these engaged in the transfer problem immediately, and 16 others after a 12-minute delay during which they read an article. Thirty-two participated initially as members of pairs; subsequently, 16 of these participated immediately in the transfer problem, and 16 others after a 12-minute delay. Sixty-four Ss participated initially as members of 16 quads; subsequently 16 of these engaged in the transfer problem immediately, and 16 others after a 12-minute delay. The 32 Ss from the quads who did not participate in the transfer phase were eliminated randomly. Similarly, all Ss were assigned randomly to the immediate and delay transfer problems.

Table 8

Distribution of Subjects by Treatments—Individuals, Pairs, and Quads—
Initial Learning and Transfer Conditions

Treatment group	Initial learning	Immediate transfer	Delay transfer
Individual	32	16	16
Pair	32	16	16
Quad	64	16	16

In the initial learning situation, four concepts in sequence were attained by the Ss as individuals, in pairs, or in quads. A 4 × 4 Latin square design was used in assigning each of the 4 sequences of concepts to the individuals, pairs, and quads. Each S, whether having learned initially as an individual, in a pair, or in a quad, worked the same transfer problem.

The Ss appeared at the Learning Laboratory and, after a brief introduction with the experimenter, received the following instructions:

> "This experiment is concerned with how people attain concepts. You are going to have an opportunity to attain several concepts. You will be shown a display of cards with various borders, figures, and colors. (The S was then shown a 32-card display board. The two defining characteristics of each attribute were pointed out, i. e., one or two figures, large or small figures, solid or textured figures, red or green figures, and circular or elliptical figures.) Notice that each card is different. There are, however, a number of ways that the cards may be grouped so that they possess some common feature or features. For example, all cards with circular figures could be grouped together. Can you show me what cards on this display board would belong to such a group? (The experimenter waited until the S had pointed out all the cards that had circular figures.) That is very good. We might also group together all the cards with red ellipses on them. Can you show me which cards would belong to this group? (Again the experimenter made sure the S found all positive instances.) O.K., that is fine.
>
> "When I said all red ellipses could be grouped together, I was stating a rule or a concept for classifying the display. In this experiment, your job will be to find out what rule I have used for grouping a series of similar cards.
>
> "The procedure is as follows. At the beginning I shall show you one card which is a member of the concept to be attained. Then you are to select other cards which you want to test as belonging to the same concept. You may select a card for testing by reading off the number you see right below it. Each time you test a card, I shall tell you if it is a member of the concept. As you find out what cards do and do not belong to the concept,

> you can determine the concept. Whenever you think you know it, you may stop, and check it here. We use this form for this purpose. (The experimenter then showed the S how to fill out a checkoff slip.) If the concept is correct, the problem is over. If it is not I shall simply say 'not correct,' and you will continue testing cards until you again feel you know what the concept is. You may offer as many concepts as you like. The job, however, is to get the concept as quickly as possible.
>
> "Do you have any questions?"

The instructions were read to the individuals, pairs, and quads. To each pair and quad the additional instructions were given that they should talk freely with one another while attaining the concepts and that any S could offer a card choice or a concept. No other instructions were given and no leader or spokesman for any pair or quad was designated.

Upon receiving the instructions, the Ss worked at the task according to the three treatment groups. The Ss who did not engage in the immediate transfer problem left the laboratory and were instructed to read an article. After 12 minutes they were brought back to the laboratory for the delay transfer problem. The four initial concepts and the immediate and delay concepts were attained in a period of 30 - 60 minutes, depending upon the efficiency of the S.

Results

There were 32 Ss who learned initially as individuals, but only 16 pairs and 16 quads. Therefore, in the analysis of the initial learning, 16 individuals were eliminated randomly in order to have the same N in the analysis of variance for initial learning, immediate transfer, and delay transfer. For the same reason, 32 of the 64 Ss who learned initially as members of quads were eliminated randomly from participation in the transfer part of the experiment.

The mean time to attain the four concepts initially was computed for each individual, pair, and quad, yielding a total of 48 scores, 16 for individuals, 16 for pairs, and 16 for quads. In both the immediate and in the delay transfer condition, there were 16 who had learned initially as individuals, 16 in pairs, and 16 in quads.

In Table 9 are given the mean scores. As may be observed, the rank order in efficiency of performance in initial learning was quads (3.27 minutes), pairs (3.89), and individuals (4.62). However, in immediate transfer, the Ss who learned initially as individuals were most efficient (2.34), with time-to-criterion about half that of the Ss who now worked as individuals but had learned initially in pairs (4.82) and quads (4.62). In delay transfer the rank order of efficiency was individuals, pairs, and quads, but the differences were not so large as for immediate transfer.

Table 9

Mean Time in Minutes for Initial Learning and Transfer According to Treatments

Treatment group	Initial learning	Immediate transfer	Delay transfer
Individuals	4.62	2.34	3.40
Pairs	3.89	4.82	3.57
Quads	3.27	4.62	4.01

Three one-way analyses of variance were computed on initial learning scores, immediate transfer, and delay transfer.

The F-ratio shown in Table 10 for initial learning indicates that the difference among the three treatment groups was significant beyond the .01 level. Subsequent t-tests of the initial learning scores between treatment groups showed the pairs to be significantly better than the individuals at the .10 level, the quads better than the pairs at the .10 level, and the quads more efficient than the individuals at the .01 level.

For immediate transfer, the difference among treatment groups was significant beyond the .05 level. T-tests between sets of means showed that the Ss who had learned as individuals were significantly more efficient than those who had learned in pairs or in quads at the .05 and .01 levels, respectively. Although in the same relative rank order, the difference among treatment groups was not significant for the delay transfer condition.

Table 10

Results of Three On-Way ANOVA's on Time-to-Criterion for Initial Learning and Transfer Conditions by Group Size

Source	Initial learning			Immediate transfer			Delay transfer		
	df	MS	F	df	MS	F	df	MS	F
Between group	2	7.71	6.42**	2	30.40	4.72*	2	1.60	<1
Error	45	1.20		45	6.44		45	4.95	

$^{*}p < .05$

$^{**}p < .01$

EXPERIMENT 4: EFFICIENCY OF INITIAL LEARNING AND TRANSFER BY INDIVIDUALS, AND GROUPS OF VARYING SIZE, INCLUDING SIXES

It was shown previously that the rank order for attaining concepts of two relevant attributes initially was quads, pairs, and individuals; however, the rank order for subsequently attaining transfer problems immediately and after a 12-minute delay was reversed, namely, individuals, pairs, and quads. The difference in time-to-criterion among individuals, pairs, and quads was significant at the .01 level on initial learning, at the .05 level for immediate transfer, but not significant at the .05 level for delay transfer. Because the reversal in performance by those who learned initially as individuals and quads is of considerable significance, a partial replication of the initial experiment was done, using half the number of Ss and using concepts of two and three relevant attributes rather than only concepts of two relevant attributes.

This experiment was run during the second semester, 1962-1963.

Subjects

Sixty-four Ss were drawn randomly from classes in educational psychology. They were told that participation in the experiment was a requirement of the course and that the main results would be reported back to them toward the end of the semester. All the Ss were females in the age range of 21-25; the median and modal age was 21.

Experimental Material

The 128 OF was used. In this experiment all the Ss attained concepts of three relevant attributes in the initial learning situation. There were four concepts to be attained in the initial learning situation by each individual, pair, and quad. These concepts were broken borders—green—circles, two borders—one—small figure, solid borders—solid—red figures, one—large—spotted figure. In the transfer situation, half the Ss attained concepts of three relevant attributes and half had concepts of two relevant attributes. These concepts were: one border—one—ellipse, one border—ellipses. Each S had to attain one concept in the transfer situation.

Experimental Procedure

Table 11 shows the design of the experiment. Assignment to the three treatment groups was random. Sixteen Ss participated as individuals in the initial learning situation; subsequently 8 of these engaged in the transfer problem immediately, and 8 others after a 12-minute delay during which they read an article. Sixteen participated initially as members of pairs; subsequently, 8 of these participated immediately in the transfer problem, and 8 others after a 12-minute delay. Thirty-two Ss participated initially as members of 8 quads; subsequently 8 of these engaged in the transfer problem immediately, and 8 others after a 12-minute delay. The 16 Ss from the quads who did not participate in the transfer phase were eliminated randomly. Similarly, all Ss were assigned randomly to the immediate and delay transfer problems.

Table 11

Distribution of Subjects by Treatments—Individuals, Pairs, and Quads—Under Initial Learning and Transfer Conditions

Treatment group	Initial learning	Immediate transfer	Delay transfer
Individual	16	8	8
Pair	16	8	8
Quad	32	8	8

In the initial learning situation, four concepts in sequence were attained by the Ss as individuals, in pairs, or in quads. A 4 × 4 Latin square design was used in assigning each of the 4 sequences of concepts to the individuals, pairs, and quads.

The Ss appeared at the Learning Laboratory individually, in pairs, or in quads. The task for the S was to identify concepts that the experimenter had selected. Instructions were in three parts and exactly as for Experiment 3. They are now summarized briefly. First, the experimeter described the display board to the S, pointing out the attributes and defining characteristics incorporated on the cards. Second, for demonstration purposes, the experimenter pointed out positive and negative instances of a sample concept he had selected and stated to the S. Third, more specific instructions were given. The experimenter pointed out a card that had the attributes which defined the first concept the experimenter had selected for the individual, pair, or quad to attain; This card was called the focus card. The individual, pair, or quad was then directed to choose one card at a time from the display. If the card had three relevant attributes which defined the concept, the experimenter responded "yes," if it did not the experimenter said "no." The S̲ was instructed initially to state (hypothesize) the concept whenever she thought she knew what it was. If this hypothesis was correct, the first concept of the series was attained: if not, she was told "incorrect," and to continue selecting cards.

The instructions were read to the individuals, pairs, and quads. To each pair and quad the additional instructions were given that they should talk freely with one another while attaining the concepts and that any S̲ could offer a card choice or a concept. No other instructions were given and no leader or spokesman for any pair or quad was designated. Time-to-criterion was recorded with a stop watch.

Upon receiving the instructions, the S̲s worked at the task according to the three treatment groups. The S̲s who did not engage in the immediate transfer problem left the laboratory and were instructed to read an article. After 12 minutes they were brought back to the laboratory for the delay transfer problem. The four initial concepts and the immediate and delay concepts were attained in a period of 30 - 60 minutes, depending upon the efficiency of the S̲.

Results

The mean time to attain the four concepts initially was computed for each individual, pair, and quad, yielding a total of 24 scores, 8 for individuals, 8 for pairs, and 8 for quads. In both the immediate and in the delay transfer condition, there were 8 who had learned initially as individuals, 8 in pairs, and 8 in quads.

In Table 12 are given the mean scores for the initial experiment and the current replication. As may be observed, the rank order in efficiency of performance in initial learning in both experiments was quads, pairs, and individuals. The scores are somewhat higher for the replication than for the initial experiment, indicating that concepts of three relevant attributes were more difficult than concepts of two relevant attributes.

Table 12

Mean Time in Minutes for Initial Learning and Transfer According to Treatment Group

Experiment	Treatment group	Initial learning	Immediate transfer	Delay transfer
Initial	Individuals	4.62	2.34	3.40
	Pairs	3.89	4.82	3.57
	Quads	3.27	4.62	4.01
Replication	Individuals	5.20	3.56	4.84
	Pairs	4.81	4.84	4.84
	Quads	3.70	4.01	4.19

Table 13 gives the results of three one-way analyses of variance for initial learning, immediate transfer, and delay transfer. The difference in time-to-criterion for concepts of two and of three attributes was not significant; therefore, they were combined. The F-ratio for initial learning is statistically significant between the .05 and .10 level, with the quads being most efficient, pairs second, and individuals least. The F-ratios for immediate and delay transfer are not significant, and only in immediate transfer was the mean actually lower for individuals than for those who had initially learned in pairs and quads. Thus, the same conclusion was found for initial learning and for delay transfer in the two experiments. However, the significant difference favoring individuals in immediate transfer was not found in the replication as was the case in the prior experiment. One highly inefficient individual in delay transfer, who took about 8 minutes longer than the mean time, resulted in individuals being higher than quads.

Table 13

Results of Three One-Way ANOVA's on Time in Minutes for Initial Learning and Transfer Conditions by Group Size, Partial Replication

Source	Initial learning			Immediate transfer			Delay transfer		
	df	MS	F	df	MS	F	df	MS	F
Between group	2	4.95	3.09*	2	3.40	< 1	2	1.13	< 1
Error	21	1.60		21	6.65		21	11.53	

*$.05 < p < .10$

Five measures were secured through analyzing the responses of individuals, pairs, and quads to determine why the significant difference occurred in time-to-criterion for initial learning. Table 14 shows the rank order for individuals, pairs, and quads for the five measures and the three on which the difference was statistically significant. A Chi-square test was run on the incidence of individuals, pairs and quads above or below the combined median of the total number on the various measures and the χ-square value and level of significance are given.

As shown in Table 14, differences on the first three measures were significant; individuals attained the concepts with the fewest card choices, with the least amount of redundant information, and by making the fewest card choices prior to the first hypothesis. Despite this, the individuals took more time to attain the concepts. The individuals, pairs, and quads secured nearly identical amounts of information potentially prior to offering a first hypothesis and also made a nearly identical number of incorrect hypotheses during the initial learning.

Table 14

Summary of Ranks Among Individuals, Pairs, and Quads, Initial Learning, Partial Replication

Measure	Individual	Pairs	Quads	Chi-square value	Level of significance
Number of concepts attained with fewest total card choices	1	3	2	6.33	.05
Number of concepts attained with least redundant information	1	3	2	5.25	.10
Number of concepts attained with fewest card choices to first hypothesis	1	2	3	21.00	.001
Least potential information acquired prior to offering a first hypothesis	1	2	3	<1	N.S.
Fewest number of incorrect hypotheses	1.5	1.5	3	<1	N.S.

On the basis of the above comparisons the following interpretation is possible. During initial learning pairs and quads made card choices more rapidly than did individuals. Not only did they make card choices more rapidly, they cognized the potential information more rapidly, even though they made more redundant choices (tested the same attribute). Further, they remembered the information and inferred the correct concept equally as well as the individuals, but in less time. Pairs and quads then secured information more rapidly and analyzed it equally as well as the individuals who proceeded at a slower pace.

The same five measures yielded no significant difference on the combined transfer situations; the Ss who had learned as members of pairs and quads did not perform significantly differently from those who had learned initially as individuals.

Group Size of Six

An extension of Experiment 4 was made to include a fourth group size, that of sixes. A total of 48 Ss in eight groups of six were included.

The overall mean time of the initial learning of the group of six was 3.65 minutes, which is 0.06 of a minute less than the mean time for quads. An ANOVA was computed on the initial learning times which include the groups of sixes. The summary ANOVA is given in Table 15.

Table 15

Summary ANOVA for Group Experiment Including Sixes, Partial Replication

Source	SSq	df	MSq	F-ratio
Corr SSg	687.18	127		
Group Size	59.10	3	19.70	4.25*
Sequence	9.52	3	3.17	< 1.00
Ordinal Position	83.86	3	27.95	6.04*
Problem	14.83	3	4.94	1.07
Grp × OP	31.66	9	3.52	< 1.00
Grp × Prob	38.80	9	4.31	< 1.00
Subtotal	237.77	30		
Residual	449.41	97	4.63	

*Significant at .01 level

The results of this ANOVA were the same as for the previous ANOVA without the sixes included. That is, ordinal position and group size were significant effects. A subsequent Duncan Multiple Range Test indicated that the difference between quads and sixes was not significant (the range was .65).

The means for the four group sizes are given by ordinal position in Table 16.

The increase in the fourth ordinal position over the third ordinal position for sixes and for individuals is atypical and may be due to one or a combination of uncontrolled factors of which the researchers are unaware.

Table 16

Mean Time in Minutes on Initial Learning by Ordinal Position and Group Size, Partial Replication

Group Size	Ordinal Position 1	2	3	4	Total Mean
Individual	6.03	6.18	3.89	4.71	5.20
Pair	6.86	4.03	4.64	3.72	4.81
Quad	4.87	3.48	3.53	2.94	3.71
Six	4.96	3.46	2.66	3.51	3.65

A Comparison of Strategy Usage and Group Size in Both Experiments

Related to Experiments 3 and 4, it was hypothesized that the strategies of individuals and groups are related to the efficiency of attaining concepts. The data from the two experiments were combined to test this hypothesis. However, only one-half of the data for Experiment 3 were used; namely, those from the second block of 64 Ss. The Ss for the first block had been run prior to the initiation of Project 1442. The combined distribution for initial learning and transfer of the second block of Experiment 3 and Experiment 4 appear in Table 17.

Table 17

Distribution of Strategies on Initial Learning and Transfer Problems by Strategy and Group Size, Initial Experiment and Partial Replication

Strategy	Initial Learning			Transfer		
	I's	Pairs	Quads	I's	Pairs	Quads
Gh	4	5	5	0	2	1
Ca	3	9	11	8	5	2
Cb	5	9	8	7	5	4
Gi	48	31	32	10	12	21
Cc	4	10	8	7	8	4

Following the separate analyses previously described, separate one-way ANOVAS for strategy on the combined time-to-criterion, initial learning data of the two experiments were computed for each group size. The summary ANOVAS for these analyses are given in Tables 18, 19 and 20. The corresponding mean times for the experiments separately and the combined experiments appear in Table 21.

The F-ratios of the ANOVAS in all cases were significant at the .001

Table 18

Summary One-Way ANOVA for Individuals on Time-to-Criterion, Initial Experiment and Replication

Source	SS	df	MS	F
Corr SSg	430.09	63		
Strategy	140.74	4	35.18	7.18*
Residual	289.35	59	4.90	

*p < .001

Table 19

Summary One-Way ANOVA for Pairs on Time-to-Criterion, Initial Experiment and Replication

Source	SS	df	MS	F
Corr SSg	347.45	63		
Strategy	105.44	4	26.36	6.43*
Residual	242.01	59	4.10	

*p < .001

Table 20

Summary One-Way ANOVA for Quads on Time-to-Criterion, Initial Experiment and Partial Replication

Source	SS	df	MS	F
Corr SSg	206.02	63		
Strategy	83.09	4	20.77	9.99*
Residual	122.93	59	2.08	

Table 21

Mean Time in Minutes by Strategy, Group Size, Initial Experiment, and Partial Replication

		Strategy				
Experiment	Group Size	Gh	Ca	Cb	Gi	Cc
Initial Experiment	I's	1.85	--	2.74	5.22	2.64
	Pairs	2.40	2.21	3.79	5.91	4.55
	Quads	1.57	2.39	2.08	4.72	4.52
Partial Replication	I's	1.74	1.83	1.94	6.45	4.82
	Pairs	2.82	2.95	3.42	5.41	5.34
	Quads	2.36	2.17	2.22	4.59	3.69
Combined Experiment	I's	1.77	1.83	2.43	5.78	3.73
	Pairs	2.73	2.29	3.67	5.60	4.94
	Quads	2.20	2.31	2.13	4.65	4.21

level; that is, the strategies used by individuals, pairs, and quads were related significantly to efficiency of concept attainment. The order of efficiency in each case may be determined by inspection of Table 21. The orders are not the same for the group sizes; however, the same group of strategies, Gh, Ca, and Cb, as in previous experiments were the more efficient ones and Gi and Cc were less efficient.

In the use of the efficient strategies the individuals had the lower times. However, they had the highest mean time for the inefficient Gi strategy, which accounted for the greatest number of frequencies of strategy usage. The pairs showed higher mean times than the quads for both the efficient and inefficient strategies.

EXPERIMENT 5: RELATIONSHIPS AMONG STRATEGIES, EFFICIENCY, AND SELECTED COGNITIVE AND AFFECTIVE VARIABLES FOR YOUNGER SUBJECTS

This experiment was conducted during the second semester of the academic year, 1961-1962, in the Learning Laboratory at the University of Wisconsin.

Purposes

The purposes of the experiment

1. To ascertain the extent to which the strategies which individuals use in attaining concepts is related to efficiency of attaining concepts embedded in semantic material of high meaningfulness.

2. To determine the effects of sex, problem, sequence, ordinal position, and major field of study on efficiency of attaining concepts embedded in semantic material of high meaningfulness.

3. To ascertain the relationship of strategy and of time-to-criterion with measures of general intellectual ability, divergent thinking abilities, and values.

It should be noted that determining the effects of problem, sequence, and ordinal position is not an hypothesis of the present project. However, it was possible to determine these effects readily, and this knowledge was useful in interpreting other results.

Subjects

The Ss were 40 males and 40 females enrolled in courses in educational psychology with no S older than twenty-five or younger than twenty. The median age to the nearest year was twenty-one.

Experimental Materials

The board used with all Ss was the 64 OHM, as described previously. The four specific concepts to be attained were: Motivation—Language Skills, Presenting Information—Mathematics, Evaluation—Facts, and Classroom Management—Foreign Language. There were eight positive and fifty-six negative instances of each of these two relevant attribute concepts on the board. The positive instances, cards for each concept, were contained in either a row or a column of the board.

Besides time-to-criterion and the strategy used, a test score or other information was secured for each S as follows:

Cumulative G. P. A. from University Records.
Logical Reasoning Test by Hertzka and Guilford.
Theoretical, Economic, Aesthetic, Social, Political and Religious Values by Allport-Vernon-Lindzey.
Ideational Fluency from the Consequences Test by Christensen, Guilford and Merrifield.
Originality from the Consequences Test by Christensen, Guilford and Merrifield.
Spontaneous Flexibility from the Alternate Uses Test by Christensen, Guilford, Merrifield and Wilson.
Conceptual Foresight from the Pertinent Questions Test by Berger and Guilford.
Cleverness from the Plot Titles Test by Guilford, et al.
Ideational Fluency from the Plot Titles Test by Guilford, et al.

The reliability of the divergent thinking tests are given for males and females in Table 22. Eleven of the *rs* ranged between .62 and .89 and are considered good for these tests. The *r* of .40 is quite low. The *rs* for the other standardized tests, as reported in manuals, ranged from .87 to .95.

Table 22

Split-half* Reliability Coefficients of Divergent Thinking Tests by Test and Sex

Test	Males	Females
Pertinent Questions—Conceptual Foresight	.72	.82
Plot Titles-Obvious—Ideational Fluency	.84	.82
Plot Titles-Remote—Cleverness	.62	.68
Consequences-Obvious—Ideational Fluency	.89	.72
Consequences-Remote—Originality	.73	.80
Alternate Uses—Spontaneous Flexibility	.40	.86

*The reliability of the entire test was determined by the use of the formula $r_w = \frac{2 \cdot r_{\frac{1}{2}}}{1 + r_{\frac{1}{2}}}$ where $r_{\frac{1}{2}}$ is the coefficient of correlation between the scores on the two halves.

Experimental Procedure

The experimental procedure was the same as for Experiment 1, except for a slight change in the instructions given to the *S*s when reporting to the Learning Laboratory. The instructions now follow for this experiment.

INSTRUCTIONS FOR THE 64 OHM

"This experiment is concerned with how people attain concepts. You are going to work several problems in concept attainment. Your performance in the experiment is not related to your course grade.

"Here is a display of 64 cards. Each card contains four attributes. The top line (*E demonstrate throughout with large card*) on each card represents an instance of teacher method, the second line an instance of pupil-teacher interaction, the third line a learning outcome, and the fourth line a subject area. The top line always represents one of two teacher methods—classroom management or presenting information; the second line one of two pupil-teacher interactions—motivation or evaluation; the third line one of four learning outcomes—facts, motor skills, attitudes, or language skills; the fourth line one of four subject areas—mathematics, social studies, science or foreign language.

"Every card on this board is different from every other card in at least one of the four attributes just described. Take one minute to examine the board carefully at this time. (E discuss with S a positive instance of each defining characteristic for each attribute; choose cards in all quadrants of the board. Make these precisely the same for all Ss.) #67 Ventilation is an instance of classroom management. #03 To discuss of presenting information. #56 Stimulates of motivation. #94 Essay of evaluation. #21 To jump of motor skills. #40 Speaking of language skills. #79 Likes music of attitudes. #48 Comma is, of facts. #06 Geometry of mathematics. #61 Physics of science. #68 Economics of social studies. #50 German of foreign language.)

"There are a number of ways certain cards may be grouped so that all the cards in a specific group possess one or more of the same attributes. As an example, all the cards indicative of 'Evaluation in Connection with Social Studies' may be grouped together to form the concept 'Evaluation in Connection with Social Studies.' Here is one of several cards which belongs to this concept (E points to #78). You pick two cards which also belong to this concept (wait for S to pick two such cards). OK, that's fine. We mark this concept in the following manner on this slip of paper (E introduce slip and illustrate its use). The concept just discussed is what we call a concept with two relevant attributes, the relevant attributes being Pupil-Teacher Interaction and Subject Area.

"As another example, all the cards indicative of facts may be grouped together to form the concept, 'Facts.' Here is one of several cards which belongs to this concept. (E point to #90). Now you pick two cards which also belong to this concept. Now pick two cards which do not belong to this concept. We mark this concept in the following manner on this slip. The concept just discussed is a concept with one relevant attribute, that attribute being Learning Outcome.

"In this experiment your job is to attain a concept that I have selected. At the beginning of each task I shall show you one card which belongs to a concept that I have selected and which you are to attain. This card we shall call the focus card. You are to select cards which you want to test as belonging to the same concept as the focus card. Select each of your successive cards by reading off the number which is at the bottom of the card. After each selection I shall state 'yes' or 'no' depending upon whether or not the card you selected belongs to the concept. Remember from the example that a 'no' means the card does not belong to the concept. But you can secure as much useful information from a 'no' card as from a 'yes' card. As you find which cards do and do not belong to the concept you can ascertain the concept. Whenever you think you know the concept, stop and ask for a slip of paper. Then check the concept on the slip and I shall read the concept back to you so there is no misunderstanding. If your concept is correct the task is completed; if not, I'll simply say 'not correct' and you will continue selecting cards until you again think you know the concept. You may present as many concepts as you like and pick as many cards as you like. Your job is to attain the correct concept. Even though I shall record the time it takes for you to attain the correct concept, your job is to get the concept correct rather than to do it quickly and get it wrong. Are there any questions ?"

The standardized tests listed previously were administered to the Ss during regular class periods of the various sections in educational psychology courses in which they were enrolled. The scoring of tests was in accordance with the standardized procedures outlined in the manuals accompanying the tests.

Results

The method of strategy identification was identical to that reported previously in Experiment 1. The other results in two parts are derived from ANOVA of time-to-criterion and strategies and from Pearson product-moment correlations.

1. As shown in Table 23 the problem and the ordinal position effects were significant at or beyond the . 01 level. No other main effects or interactions were significant. The significant ordinal position effect provides evidence of learning across trials. The mean time-to-criterion decreased across the four trials, the means being 7.63, 4.33, 3.34, and 2.80, respectively. It will be recalled that Figure 2 showed a similar learning curve.

Table 23

Mean Squares and F-Ratios for the Effects of Sex, Sequence, Problem, and Ordinal Position for Younger Subjects

Source	df	MS	F
Sex	1	85.33	< 1.0
Sequence	3	10.62	< 1.0
Sex × Sequence	3	5.93	< 1.0
Subs./grps.	8	197.40	
Problem	3	55.19	4.85**
Ordinal Position	3	375.25	32.95**
Sex × Problem	3	14.83	1.30
Sex × Ordinal Position	3	12.77	1.12
Error	292	11.39	

**Significant beyond .01 level.

The difficult concept or problem among the four which led to the significant problem effect was "Motivation—Language Skills." The Ss apparently were unclear about the definition of a language skill.

2. In Table 24 are presented the means of time-to-criterion by major fields of specialization. A subsequent one-way ANOVA showed major field to be significant at the .05 level. The three most efficient groups of students were those with majors in home economics, speech, and foreign language. The three least efficient groups were majors in men's physical education, English, and agriculture. Students with majors in science and mathematics, who were hypothesized to be the most efficient, were in the middle. It should be noted that the Ns for all fields, especially agriculture, were small.

Table 24

Mean Time in Minutes to Attain Concepts by Major Field of Study of Younger Subjects

Major Field	N	Mean Time
Home Economics	10	3.54
Speech	14	3.62
Foreign Language	9	3.65
Science and Mathematics	17	4.56
History	14	4.63
Agriculture	2	6.06
English	10	6.20
Physical Education, Men	4	6.64

3. Table 25 gives the mean time-to-criterion, according to strategy used. The order of strategies from most to least efficient is Gh, Ca, Cb, Gi, and Cc. The subsequent one-way ANOVA showed this difference to be significant beyond the .01 level.

Table 25

Mean Time in Minutes to Attain Concepts According to Strategy for Younger Subjects

Strategy	Time
Gh	1.65
Ca	2.61
Cb	3.36
Gi	6.41
Cc	8.85

Table 26 gives the intercorrelations for males and females among time-to-criterion for each concept attained and the mean time for attaining the four concepts, the five strategies separately and a representative strategy for each S, and fourteen other variables.

When computing the rs for strategies, the measure for each strategy was the number of times that strategy was used in all four trials. Thus, the incidence of each strategy usage was actually recorded as the number to be correlated with other variables.

The representative strategy was identified as either conservative or gambler. The S's most efficient time on Trial 3 or 4 was determined. Then the strategy was identified as conservative or gambler depending upon whether the S used one of the three conservative or one of the two gambling strategies on this most efficient trial. A conservative was assigned the number 1 and a gambler zero. For example, if a S had times of 3.80 and 4.50 and used strategies Cb and Gi on trials 3 and 4 respectively, the representative strategy would be identified as conservative.

As expected the rs among trials were positive. The highest, r, .80, was between Trials 3 and 4 for males, and between Trials 2 and 3, .57, for females. The only significant positive rs—.38, .53, .55, and .32—between time-to-criterion and strategies for males were with the Gi strategy, previously reported inefficient. Negative rs of -.53, -.52, and -.33 were found with the Gh strategy for males indicating that this strategy was associated with efficient performance. For the females, also, negative rs were found, as expected, with the Gh strategy, and a positive r of .36 was found for the inefficient Cc strategy.

Table 26

Correlation Matrix of Time-to-Criterion with Other Variables for Younger Males and Females

Variable	Trial 1		Trial 2		Trial 3		Trial 4		Mean time	
	M	F	M	F	M	F	M	F	M	F
Trial 2	-.10	-.08								
Trial 3	-.17	.01	.50	.58						
Trial 4	-.29	-.13	.55	.46	.80	.28				
Mean Time	.45	.56	.68	.68	.69	.68	.62	.48		
Gi Strategy	-.29	-.08	.38	.46	.53	.25	.55	.53	.32	.37
Ca Strategy	-.01	.05	-.17	.14	-.03	.08	-.09	.16	-.12	.16
Cb Strategy	-.03	-.03	-.11	-.15	.03	-.06	.05	-.01	-.05	-.10
Gh Strategy	.19	.04	-.30	-.46	-.53	-.37	-.52	-.58	-.33	-.46
Cc Strategy	.22	.05	.14	.20	.04	.36	.00	.14	.21	.28
Representative Strategy	-.14	-.11	.09	.21	.14	.09	.00	.09	-.01	.07
GPA	-.19	.14	.09	-.17	-.10	.02	.06	-.31	-.10	-.06
Logical Reasoning	.02	-.14	.06	.03	-.04	-.05	-.07	-.04	-.01	-.08
Theoretical	-.10	-.38	.25	.00	.17	.03	.10	-.05	.11	-.24
Economic	.01	.14	.20	.06	.13	.03	.25	-.17	.21	.08
Aesthetic	-.14	.14	.08	-.15	.01	-.14	-.26	-.06	-.14	-.04
Social	.11	.05	-.02	-.20	-.08	.00	.02	.25	.04	.02
Political	-.15	.16	-.04	.04	.17	-.03	.22	.09	.01	.13
Religious	.14	-.08	-.32	.20	-.32	.12	-.26	-.02	-.22	.07
Originality	-.08	-.01	.19	-.10	-.06	.04	-.19	-.20	-.03	-.09
Ideational Fluency	.16	-.08	-.10	-.06	.05	.03	.11	.17	.10	-.01
Spontan. Flexibility	-.09	-.09	.02	-.31	-.14	-.15	-.19	-.05	-.15	-.24
Conceptual Foresight	-.07	.27	-.02	-.35	-.12	-.02	-.03	-.06	-.11	.01
Cleverness	-.03	-.29	-.03	-.14	-.17	-.10	-.15	-.19	-.24	-.33
Ideational Fluency	.14	.06	-.11	-.26	-.24	-.18	-.17	-.20	-.08	-.19

Of the remaining 70 *r*s between the time-to-criterion variables and the other 14 variables for males, only two were statistically significant at or beyond the .05 level. Of the remaining 70 *r*s between the time-to-criterion variables and the other variables for females, only three were statistically significant at or beyond the .05 level. Thus, with the relatively large proportion of significant *r*s between time-to-criterion and strategy variables and the small proportion of significant *r*s between time-to-criterion and the other variables, it can be concluded that strategies rather than other variables in the cognitive and affective domain are associated with efficiency of performance.

Table 27 shows the intercorrelations between the strategies and the fourteen other variables. Of the 70 rs for males, five are statistically significant at or beyond the .05 level and seven are for females. Ten of the 12 rs indicate that a high test score goes with frequent use of an efficient strategy—Gh, Ca, and Cb; or the converse, a low test score goes with frequent use of an inefficient strategy—Gi and Cc. For males the supporting rs are .38 economic values and Cb strategy, .33 religious values and Gh strategy, .40 conceptual foresight and Cb strategy, and -.32 ideational fluency and representative strategy, primarily Gh. For females the supporting rs are .32 economic values and Gh strategy, .47 and .42 ideational fluency and Cb strategy, -.32 ideational fluency and Gi strategy, -.31 cleverness and Cc strategy, and -.33 conceptual foresight and Gi strategy. The two exceptions are .38 religious values and Gi strategy for females and -.42 for social values and Ca strategy for males. This pattern of significant rs leads to the tentative conclusion that divergent thinking abilities are more positively associated with efficient strategies than are values or convergent thinking abilities.

In summary of the correlations, the conclusion is clear that time-to-criterion is closely associated with strategy usage and that the other variables, except divergent thinking to a minor extent, are not so associated. The previous results of ANOVA in Experiment 1 and in this experiment also indicate the close relationship between time-to-criterion and efficiency of the various strategies.

Table 27

Correlation Matrix of Strategy with Other Variables for Younger Males and Females

Variable	Gi		Ca		Cb		Gh		Cc		Repr. Str.	
	M	F	M	F	M	F	M	F	M	F	M	F
GPA	-.04	-.11	-.04	.12	.01	-.12	.00	.14	.12	-.02	-.01	.03
Logical Reasoning	.05	-.01	-.28	.13	-.16	.06	.09	-.11	.13	.12	-.02	.10
Theoretical	.16	-.10	-.01	.14	-.01	-.04	-.10	.01	-.11	.06	.19	.16
Economic	.12	-.12	.09	-.26	.38	-.19	-.31	.32	.01	-.01	.19	-.15
Aesthetic	-.04	-.14	.04	.06	-.14	.15	.01	.02	.14	-.04	.11	-.02
Social	.01	-.03	-.42	.03	.08	.14	.19	-.10	-.06	.06	-.24	-.04
Political	.12	-.14	-.07	-.09	.00	.08	-.13	.03	.10	.22	-.22	-.29
Religious	-.31	.38	.20	.04	-.20	-.19	.33	-.16	-.12	-.14	-.01	.12
Originality	-.19	-.12	-.07	-.20	.29	.01	.03	.16	.15	.02	.22	-.14
Ideational Fluency	.00	-.15	-.16	.09	.15	.47	.08	-.21	-.13	.12	.00	.23
Spontan. Flexibility	.06	.03	-.23	.21	.15	.25	-.10	-.21	.20	-.11	.03	.21
Conceptual foresight	-.10	-.33	-.06	-.13	.40	.16	.01	.17	-.08	.27	.14	-.16
Cleverness	-.08	.16	-.05	.01	.12	-.18	.01	.09	.11	-.31	-.05	-.11
Ideational Fluency	-.25	-.32	-.04	.03	-.05	.42	.20	.06	.19	-.10	-.32	.12

EXPERIMENT 6: RELATIONSHIPS AMONG STRATEGIES, EFFICIENCY, AND SELECTED COGNITIVE AND AFFECTIVE VARIABLES FOR OLDER SUBJECTS

Experiment 6 was conducted during the 8-week summer session of 1962. Experiment 6 was a replication of Experiment 5 conducted during the semester immediately preceding the 1962 summer session, except that the age and other characteristics of the Ss were different. The design, the materials, and the concepts to be attained were exact replications of those of Experiment 5. The minimum age for the summer session Ss was 25 in contrast to a maximum age of 25 for the regular semester Ss.

Subjects

The 80 Ss, 40 men and 40 women, were drawn from four sections of an educational psychology course. These summer session Ss included a high percentage of experienced teachers. The mean age of the 40 Ss was 33.85 for women and 29.63 for men, with a σ of 8.8 years and 4.9 years, respectively. The age distributions were skewed toward the lower end.

Experimental Procedure

The experimental procedure was the same as in Experiment 5.

Data Gathered

Each S received a time-to-criterion score for each of the four concepts attained in the experiment, and the strategy used by the S was identified for each concept.

The Ss were given the same battery of tests yielding a total of 13 scores, as was done in Experiment 5. However, undergraduate grade point average was not available for the summer school Ss, some of whom were special students not admitted to graduate study.

The scoring of the tests was objective, with the exception of two divergent thinking tests. The same criteria of scoring were used on all six tests of divergent thinking as in the preceding experiment. All papers were scored by the same individual, but this was not the same scorer as in the preceding experiment. Three persons, including the final scorer, scored a small sample of the tests, and the results were discussed with the scorer. A high degree of agreement was reached in the discussions. Reliability coefficients for the six scores were computed for both men and women by the split-half technique. These rs are given in Table 28. The rs of the Logical Reasoning Test and the Allport-Vernon-Lindzey Study of Values as given in the manuals appeared satisfactory.

Table 28

Reliability Coefficients for Six Divergent Thinking Scores, for Older Subjects, by Test Score and Sex

Score	Sex	
	Male	Female
Ideational fluency—Consequences Test	.82	.96
Originality — Consequences Test	.80	.00
Spontaneous flexibility — Alternate Uses Test	.78	.68
Conceptual foresight — Pertinent Questions Test	.82	.76
Cleverness — Plot Titles Test	.30	.72
Ideational fluency — Plot Titles Test	.92	.99

Results of ANOVA

The analysis of the data followed the same procedure as that for Experiment 5. The results of the ANOVA based on the Latin Square design, showing the effects of sex, sequence, ordinal position, and problems, are given in Table 29. Ordinal position, which indicates that learning took place across trials, was significant at the .01 level. Problem effect was significant at the .05 level. The mean time in minutes for each concept (problem) was A—4.84, B—6.28, C—5.38, and D—5.45. The difficult concept was the same as in Experiment 5, namely, motivation—language skills. The easy concept was presenting information—mathematics.

A one-way ANOVA showed criterion scores for the five strategies to be significant at the .01 level.

Table 29

Mean Squares and F-Ratios of the Effects of Sex, Sequences, Problem, and Ordinal Position for Older Subjects

Source	df	MS	F
Sex	1	31.34	<1.0
Sequence	3	30.84	<1.0
Sex × Sequence	3	78.23	<1.0
Subs/Grps	8	264.53	
Problem	3	28.03	2.94*
Ordinal Position	3	412.22	43.21**
Sex × Problem	3	9.99	1.05
Sex × Ordinal Position	3	11.68	1.22
Error	292		

* significant beyond .05 level
** significant beyond .01 level

For the younger Ss of Experiment 5 and the older Ss of Experiment 6, the rank order for efficiency of the strategies was the same; however, the older Ss had longer mean times. Table 30 gives the mean times, according to strategy, for the younger and older Ss. The rank order for the older Ss is Gh 2.01, Ca 3.51, Cb 5.15, Gi 6.99, and Cc 9.06.

The grand mean for younger Ss for all four concepts was 4.52 minutes and for older Ss 5.49 minutes. This difference yielded a t-value of 2.67 which, with 319 degrees of freedom, is significant at the .05 level. Thus, the younger Ss, independent of strategy use, were significantly more efficient than older Ss.

A Chi-square test on the distributions of strategy used by older and younger Ss was not significant ($x^2 = 4.85$, df = 4, p = .30). This indicates that younger subjects are more efficient, independent of strategy used. However, it may be noted from Table 30 that for younger subjects there was a slightly higher frequency of efficient strategies.

Table 30

Mean Time in Minutes and Frequency of Strategy Usage by Younger and Older Subjects

Strategy	Younger		Older	
	f	Mean Time	f	Mean Time
Gh	110	1.65	93	2.01
Ca	19	2.61	13	3.51
CB	19	3.36	17	5.15
Gi	151	6.41	168	6.99
Cc	21	8.85	29	9.06
Grand Mean		4.52		5.49

Table 31

Correlation Matrix of Time-to-Criterion with Other Variables for Older Males and Females

Variable	Trial 1		Trial 2		Trial 3		Trial 4		Mean Time	
	M	F	M	F	M	F	M	F	M	F
Trial 2	.19	.23								
Trial 3	.22	.44	.27	.57						
Trial 4	.21	.17	.22	.46	.28	.31				
Mean Time	.72	.69	.63	.78	.68	.80	.55	.60		
Gi Strategy	.13	.19	.20	.33	.34	.31	.43	.44	.38	.42
Ca Strategy	-.06	.00	-.28	-.20	-.11	-.08	-.19	-.08	-.22	-.12
Cb Strategy	-.18	-.12	.14	.02	.05	-.02	.17	-.01	.02	-.05
Gh Strategy	-.17	-.27	-.09	-.43	-.46	-.48	-.40	-.61	-.41	-.59
Cc Strategy	.23	.18	-.13	.17	.18	.25	-.13	.20	.11	.27
Rep. Strategy	.26	-.10	.08	.04	.19	-.03	.13	.28	.27	.03
Age	.09	-.33	.30	.19	-.16.	.30	-.02	.23	.09	.36
Logical Reasoning	-.20	-.40	-.20	-.19	-.15	-.14	.11	.04	-.21	-.28
Theoretical	-.07	.11	.22	.12	-.04	.11	.17	.00	.07	.13
Economic	.02	-.02	-.10	-.31	.13	.00	-.32	-.46	-.05	-.24
Aesthetic	-.12	.00	.09	.23	.21	-.11	.17	.28	.10	.12
Social	-.25	.03	.13	.09	.07	.21	.07	.03	-.03	.12
Political	.05	.05	-.21	-.32	-.05	-.02	-.10	-.37	-.10	-.20
Religious	.21	-.08	-.03	.12	-.25	-.06	.00	.23	.00	.05
Originality	.02	.01	.11	-.05	.03	.02	.28	.00	.14	-.01
Ideat. Fluency	-.29	-.23	-.17	-.11	-.21	-.15	-.15	.09	-.33	-.17
Spon. Flexibility	.16	-.09	.08	-.09	-.09	-.05	.00	.26	.07	-.02
Concep. Foresight	-.29	-.24	-.06	-.02	-.33	-.05	-.18	.03	-.34	-.11
Cleverness	-.33	-.06	-.30	-.11	-.34	-.11	-.32	-.17	-.49	-.15
Ideat. Fluency	.05	.03	.03	-.06	.04	-.10	.07	.14	.07	-.01

Required level of significance $r \geq .31$, $p < .05$; $.40$, $p < .01$.

Results of Correlational Analysis

Pearson product-moment rs among the variables were computed. Separate rs were computed for men and women. The rs for time-to-criterion and the other variables are given in Table 31.

The positive and significant rs for both sexes among time-to-criterion scores on the four concepts indicate a tendency for the Ss to exhibit the same relative efficiency over the four concepts. The negative rs between time and strategies Gh, Ca, and Cb and the positive rs between time and strategies Cc and Gi and the previous results of ANOVAS show the relatively higher efficiency of the first three strategies in comparison with the inefficiency of the last two. No rs for age of men and time-to-criterion were significant at the .05 level; three were significant for women, including an r of .36 for the mean time for all trials. Thus, for females there was a tendency for lower efficiency to be associated with increasing age. It should be recalled that the females were on the average older than the males and were also more variable in chronological age. Further, 15 of 95 Ss were dropped because they could not attain the first two concepts in the time specified.

For both men and women, most of the rs between age and logical reasoning were negative but not significantly different from 0 at the .05 level.

The rs between time-to-criterion and values indicated a tendency for economic values to be associated with efficiency of performance for men -.32 and for women -.46. Also for women political values and efficiency were similarly related -.32 and -.37 for two trials.

In connection with the divergent thinking abilities there was a tendency for the efficient performance to be associated with high scores for men, especially with cleverness, conceptual foresight, and ideational fluency as measured by the Consequences Test. For men 7 of the 30 *rs* involving tests of divergent thinking were negative and significant at or beyond the .05 level; for women most *rs* were negative but not any was significantly different from 0 at the .05 level.

Table 32 shows the *rs* between strategies and the other variables. The only significant *r* between age and strategy was .36 for females, indicating a tendency for older females to use the most inefficient Cc strategy.

Of the six Allport-Vernon-Lindzey Values, only two were correlated significantly with strategies. Women high in social values tended to use the inefficient Gi strategy and those low used the efficient Ca strategy.

Only three *rs* between the divergent thinking abilities and strategies were significant at the .05 level, indicating no consistent relationships.

The patterns of the *rs* for the older *Ss* and the younger *Ss* of Experiment 5 were much alike. There was no consistent pattern of relationships between time-to-criterion and the other variables, except strategy.

Chi-square tests on the distributions of males and females for the five strategies, as shown in Table 33, were computed for each of the younger and older groups and the total. The χ^2-value for the younger *Ss* was 0.46 with four degrees of freedom. This is not significant. The

Table 32

Correlation Matrix of Strategies with Other Variables for Older Males and Females

Variable	Strategy											
	Gi		Ca		Cb		Gh		Cc		Rep	
	M	F	M	F	M	F	M	F	M	F	M	F
Age	.08	.04	-.27	-.08	.03	-.01	-.10	-.25	.18	.36	.13	.18
Logical Reasoning	.17	.07	.10	.24	.12	-.15	-.12	-.15	-.27	.10	-.09	.29
Theoretical	.03	-.01	-.07	.15	.15	-.13	-.07	-.08	.00	.18	.16	-.01
Economic	-.02	-.15	.11	.27	-.09	.02	-.08	.13	.17	-.12	.15	-.19
Aesthetic	.10	.03	.05	.00	-.01	.07	-.17	.04	.09	-.17	-.18	.02
Social	.01	.41	.02	-.42	-.07	-.03	.16	-.17	-.26	-.19	-.02	-.22
Political	.05	-.24	.09	.08	-.22	.32	.03	.18	-.03	-.19	.14	-.06
Religious	-.11	.00	-.16	-.14	.25	-.13	.12	-.01	-.07	.22	-.08	.13
Originality	.04	.18	.01	-.13	.06	.02	-.18	-.06	.17	-.18	-.11	-.06
Ideat. Fluency	.02	-.05	.20	.10	.20	.13	-.05	-.12	-.23	.09	-.14	.30
Spon. Flexibility	-.19	.15	.05	.05	.15	-.17	.11	-.17	.03	.13	.03	.22
Concept. Foresight	-.15	-.02	-.01	.10	.12	.05	.21	-.03	-.15	-.02	.04	.23
Cleverness	-.06	-.31	.06	.01	.03	.07	.03	.13	-.01	.29	-.11	.18
Ideat. Fluency	-.02	-.10	.31	.02	.21	-.09	-.24	-.03	.11	.31	-.01	.05

required level for significance $r \geq .31$, $p < .05$; .40, $p < .01$.

χ^2-value for the older Ss was 9.06. With four degrees of freedom the probability of this great a value by chance is between .10 and .05, approximately .06. The large contribution to the significant difference between older males and females comes from the frequencies of the inefficient Gi and Cc strategies. However, the males are high on the Gi and the females high on the Cc. The χ^2-value for the total was 6.04 which is not significant.

Table 33

Distribution of Strategies of Younger and Older Subjects by Sex for Two Experiments

Strategy	Younger		Older		Total	
	M	F	M	F	M	F
Gh	54	58	41	52	95	110
Ca	9	10	7	6	16	16
Cb	9	10	6	11	15	21
Gi	77	72	96	72	173	144
Cc	11	10	10	19	21	29

Comparison of the correlations for Younger and Older Subjects

Although a few rs between the various variables, other than strategy, and time-to-criterion were significant at the .05 level, there was no definite pattern for younger or older Ss of either sex. In the absence of a pattern of significant rs, it is concluded that the variables, other than strategies, used in this study are not associated with efficiency of attaining concepts. The low negative rs for conceptual foresight and cleverness poses the possibility for further research.

Strategies also do not correlate significantly with any variable except time-to-criterion. On the basis of these correlations and also upon the findings in the previous experiments, strategies are clearly related to efficiency of attaining concepts and the other variables are not.

The Ss of this report represent unique samples relative to cognitive and affective characteristics in that they were drawn from a highly selected university population. The range in cognitive, and probably in affective, characteristics is less than for the general population of adults of the same age range.

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level; that is, the strategies used by individuals, pairs, and quads were related significantly to efficiency of concept attainment. The order of efficiency in each case may be determined by inspection of Table 21. The orders are not the same for the group sizes; however, the same group of strategies, Gh, Ca, and Cb, as in previous experiments were the more efficient ones and Gi and Cc were less efficient.

In the use of the efficient strategies the individuals had the lower times. However, they had the highest mean time for the inefficient Gi strategy, which accounted for the greatest number of frequencies of strategy usage. The pairs showed higher mean times than the quads for both the efficient and inefficient strategies.

EXPERIMENT 7: A FURTHER STUDY OF EFFICIENCY OF CONCEPT ATTAINMENT ACCORDING TO MAJOR FIELDS OF STUDY

In the second semester, 1963-64, 94 females participated in an experiment. In this experiment two types of concepts were attained: one type in which the S had to select cards for testing as has been described previously, the other type in which all the cards necessary to attain the concept were presented simultaneously to the S and from which he inferred the concept.

The material used was the 64 OF. The two concepts for which the S had to do his own card selection were: Solid Border—Green Circles, One—Large Figure. The four concepts to be attained for which all the relevant cards were presented were Two Borders—Red Figures, One Border—Two Circles, Two—Green Figures, Two Borders—One Ellipse.

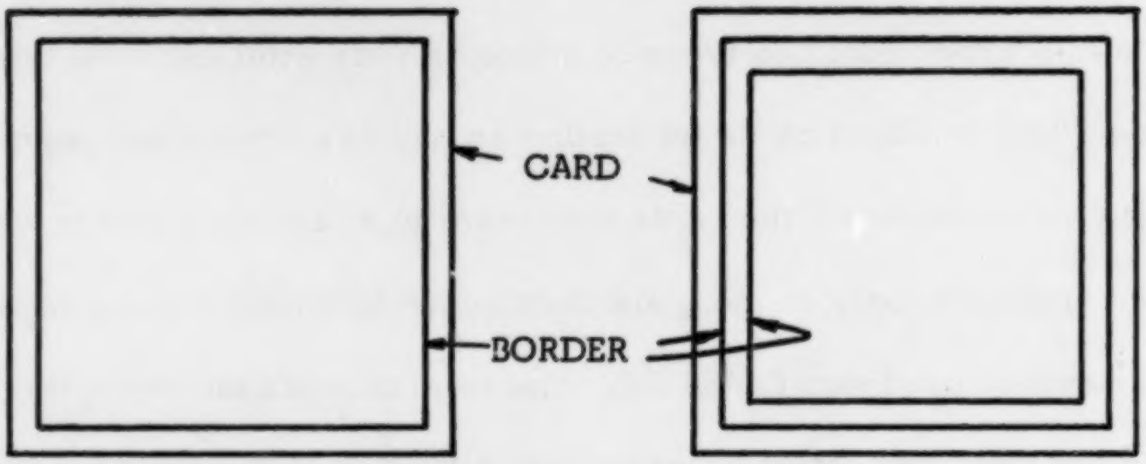
Each S reported individually to the Learning Laboratory. The instructions for attaining the concepts for which the S did the selection were similar to those described previously in Experiments 5 and 6. The instructions to attain the other four concepts were somewhat different in that nothing was indicated about the selection process. Both sets of instructions for the first two problems were as follows:

> "This experiment is concerned with how people attain concepts. You are going to have an opportunity to work several exercises in concept attainment.

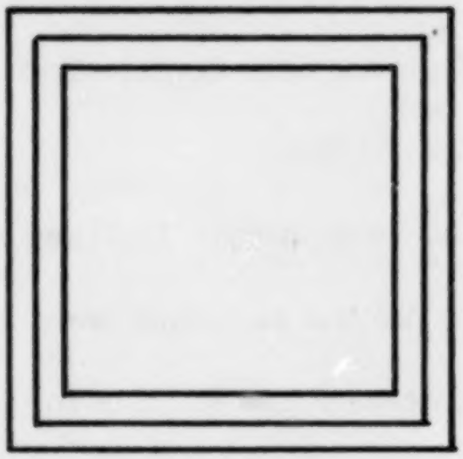
"The exercises will be performed by using the 64-card board located directly in front of you.

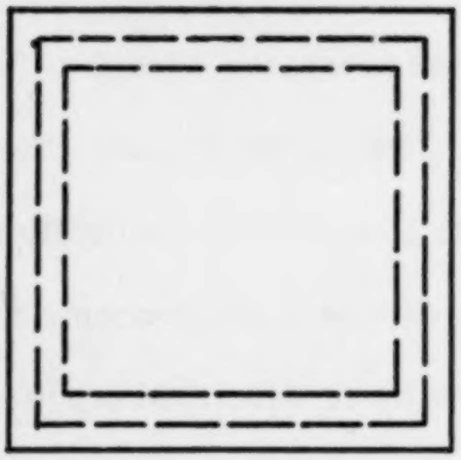
"Every card on the board is different from every other card. However, there are a number of ways of reducing each card to 6 basic dimensions.

"Note that all cards have either one or two borders."



Also note that the borders are either solid or broken.





In this study the mean time to attain concepts, as shown in Table 34, was much alike for the seven groups of Ss. On the problems in which the instances were selected, the mathematics and science group was most efficient and home economics was least efficient. On the four problems in which all of the instances were presented, the English group was most efficient followed closely by home economics and foreign language; the speech therapy and history groups were least efficient.

Table 34

Mean Time in Minutes on Two Types of Concept Attainment Problems According to Subject Fields

Subject Field	N	Two Selection Problems	Four Presented Problems
Math and Science	7	5.91	1.32
English	17	6.18	1.18
Speech Therapy	28	6.34	1.49
Other	9	6.61	1.32
History	9	6.76	1.65
Foreign Languages	13	6.85	1.25
Home Economics	11	7.03	1.29
TOTAL	94		
MEAN		6.50	1.37

As shown in Table 35 and in Table 36, the differences among the groups were not statistically significant at the .05 level.

Table 35

Summary of One-Way ANOVA for Four Presented Problems

Source of Variation	df	MS	F
Major Field	6	.348	< 1
Residual	87	.603	

Table 36

Summary of One-Way ANOVA for Two Selection Problems

Source of Variation	df	MS	F
Major Field	6	1.71	< 1
Residual	87	5.32	

In a previous study, part of Experiment 5, the difference among the groups was significant but in this study it was not. This is probably due to either of two factors. First, the type of material in which the concepts were imbedded was changed from the first to the second study. Second, the instructions were read to the S at about the same speed in the first study but were read by the S in the second study and this allowed for considerable variability in rate of reading. Since both variables were changed from the first to the second study, the source of the difference between the two studies cannot be determined.

EXPERIMENT 8: EXPLORATORY STUDY OF INSTRUCTING YOUNGER SUBJECTS TO USE CONSERVATIVE AND GAMBLING STRATEGIES

During the first semester 1962-63, the attempt was made to teach Ss to use the Ca or Gh strategy, as previously defined, and subsequently three different sets of instructions and a principle were developed and tried out.

The Ss were drawn from populations of students enrolled in educational psychology courses at the University of Wisconsin. They were males and females of junior or senior standing. Ninety Ss were used in the attempt to teach the two strategies and 30 were used in developing the instructions. The 81 OHM and the 27 OHM were used.

The task consisted of attaining a series of conjunctive concepts as in previous experiments. The general experimental procedure was similar to that previously employed. The number of concepts the Ss attained was varied as this exploratory experiment proceeded. Initially the Ss attained four concepts and at no time were there fewer than four attained.

The marked difference in this experiment from previous experiments was to vary the instructions given the Ss. At the outset, three different sets of instructions were developed. Two of these were intended to instruct the S in the use of strategy Ca and Gh. The third or control set were general instructions, as previously used, with no information or instructions concerning strategy. The final revisions of the conservative and gambling instructions are included in Experiment 9.

The task on the 81-card board proved too difficult for the Ss instructed in the gambling strategy. Most Ss could not attain a concept in a time limit of 15 minutes per concept. As a result, the task was shifted to the 27-card board. This board, although easier for the Ss using the gambling strategy, proved too easy for those instructed in the conservative strategy.

At this point two major changes were made. A shift was made to the 128 OF. The second change was in the instructions. Six sets of instructions were developed, consisting of minimal, structure, and conservative strategy, and each of these three in combination with a principle for obtaining information from negative and positive instances of the concept to be attained.

The operational definitions of these terms relative to the instructions now follow:

Minimal:	Clarification and illustration of a concept and a description of the mechanics of picking cards and offering concepts.
Structure:	Clarification and illustration of each of the seven attributes found on the cards.
Conservative Strategy:	Clarification of a procedure for varying each successive card choice one and only one attribute from the focus card.
Principle:	Clarification of a procedure for drawing the correct inference from "yes" and "no" cards when varying one and only one attribute from the focus card.

When first trying out the instructions, the Ss were instructed to indicate why they had difficulty in understanding or executing the instructions. Thus, the instructions were revised and clarified as the experimentation progressed. The time-to-criterion and other objective data were inspected but not analyzed by statistical techniques since the primary purpose of this experimentation was the development and refinement of the instructions. The final sets of instructions appear in the treatment of the next experiment.

From both preliminary attempts to teach Ss the use of strategies, it was concluded that the conservative strategy could be taught to Ss and, in turn, this strategy could be used with any board. The gambling strategy, which incorporated a time limit within which to offer a concept and also the varying of card choices from the focus card by more than one attribute, could be understood and executed by the S using only a small amount of stimulus material. The final sets of instructions with and without the principle could be executed quite well by most Ss.

EXPERIMENT 9: THE EFFECT OF A PRINCIPLE AND INSTRUCTIONS INCORPORATING THREE TYPES OF INFORMATION UPON EFFICIENCY OF CONCEPT ATTAINMENT FOR YOUNGER SUBJECTS

This experiment was conducted during the summer session of 1963.

Purposes

The purposes of this experiment were to determine the effects of three types of instruction and of a principle upon efficiency of attaining concepts. The three types of instructions, or treatments, to be described more fully later, were designated minimal, structure, and conservative.

Subjects

The Ss were fifteen females and two males for each of six cells, a total of ninety females and twelve males. They were thirty years of age or younger, with a range in age from nineteen to thirty. These Ss were drawn randomly from the total population enrolled in the summer session classes in educational psychology.

Experimental Material

The 128 OF was used. The concepts to be attained were conjunctive and of three relevant attributes, such as broken borders—green—circles.

Experimental Procedure

As stated earlier, three types of instructions were used: minimal, structure, and conservative. A principle or no principle was included in the instructions to an equal number of Ss in each treatment. The Ss were randomly assigned to the three types of instruction and to principle or to no principle.

Now follow the instructions for the Ss who did not get the principle as part of their instructions. After the three sets of instructions, the principle is given. This principle was given to half the Ss, and it was given immediately before the last paragraph of the three types of instructions.

MINIMAL WITHOUT PRINCIPLE

"This experiment is concerned with how people attain concepts. Your task is to attain several concepts that I have in mind. I am going to teach you how to attain the concepts. Your performance today in no way reflects on your intelligence. Also, there is nothing tricky about the experiment."

"Now let us define what a concept is on this board. Concepts on this board are stated in terms of one or more of seven attributes listed on this slip of paper. For example, all the cards containing circular figures form the concept, circles. Show me four cards which belong to this concept. (E waits until S points out four examples.) That's correct. Consider another example. All the cards with small, red, elliptical figures form the concept "small, red, ellipses." Show me four cards which belong to the concept, "small, red, ellipses." (Again E make sure S knows four examples of "yes-cards.") That's correct. A very large number of concepts can be formed, having one, two, or any combination of the 7 attributes that are listed on your slip of paper. Please state a one-, then a two-, and then a three-attribute concept. . . That's fine. In this experiment, your job is to attain concepts of the type we have just discussed. Do you have any question about what a concept is?"

"Listen carefully now to the procedure for attaining a concept that I have in mind. I shall indicate one card which belongs to the concept. This card we shall call the focus card. This focus card contains all 7 attributes, and part of these 7 attributes form the concept I have in mind. Your job is to test attributes of other cards in relation to the focus card to determine which attributes form the concept. Read off the number of the card you are checking and I shall tell you 'yes' if it belongs to the concept and 'no' if it does not belong to the concept."

"When you think you know the concept, mark it on the slip of paper and give it to me. If the concept is correct, the task is completed. If not, I'll simply say 'not correct, continue' and you will continue selecting cards until you again offer a concept. Use the slip of paper at all times and take it to the board with you.

"Your job is to ascertain the correct concept as quickly as possible. Do you have any questions ?"

STRUCTURE WITHOUT PRINCIPLE

"This experiment is concerned with how people attain concepts. Your task is to attain several concepts that I have in mind. I am going to teach you how to attain the concepts. Your performance today in no way reflects on your intelligence. Also, there is nothing tricky about the experiment.

"Now, let us examine the structure of the material. (E point to the board.) There are 128 cards on this board. This slip of paper, which you need throughout the experiment, lists the attributes contained on each card on the board. Pick any one card on the board and point out the seven attributes, listed on your slip of paper, which are also on the card. Do your checking aloud so that I may follow you. Start with number of borders. (E check that S follows the sequence given on the slip and checks all attributes.) Do you understand that any card you would have chosen would have all the 7 attributes ? Do you have any questions on the 7 attributes contained on each card ?

"Now let us define what a concept is on this board. Concepts on this board are stated in terms of one or more of the seven attributes. For example, all the cards containing circular figures form the concept, circles. Show me four cards which belong to this concept. (E wait until S points out four examples.) That's correct. Consider another example. All the cards with small, red, elliptical figures form the concept 'small, red, ellipses.' Show me four cards which belong to the concept, 'small, red, ellipses.' (Again E make sure S knows four examples of 'yes-cards.') That's correct. A very large number of concepts can be formed, having one, two, or any combination of the 7 attributes that are listed on your slip of paper. Please state a one-, then a two-, and then a three-attribute concept. . . That's fine. In this experiment, your job is to attain concepts of the type we have just discussed. Do you have any questions about what a concept is ?

"Listen carefully to the procedure. I shall indicate one card which belongs to the concept. This card we shall call the focus card. Then you are to choose cards one at a time which you want to test as belonging to the concept. After each choice I shall state 'yes' or 'no' depending upon whether or not your choice belongs to the concept. When you think you know the concept, mark it on this slip of paper and give it to me. If the concept is correct the task is completed. If not I'll simply say 'not correct, continue' and you will continue selecting cards until you again offer a concept. Use the slip of paper at all times and take it to the board with you.

"Your job is to ascertain the correct concept as quickly as possible. Do you have any questions ?"

CONSERVATIVE WITHOUT PRINCIPLE

"This experiment is concerned with how people attain concepts. Your task is to attain several concepts that I have in mind. I am going to teach you how to attain the concepts. Your performance today in no way reflects on your intelligence. Also, there is nothing tricky about the experiment.

"First, I shall try to explain the structure of the material on this board with which you are going to work, so that you understand it; second, I shall explain what concepts are, using the material on the board; last, I shall teach you a step-by-step procedure that you are to follow in attaining the concept that I have in mind.

"Now, let us examine the structure of the material. (E point to the board.) There are 128 cards on this board. This slip of paper, which you need throughout the experiment, lists the attributes contained on each card on the board. Pick any one card on the board and point out the seven attributes, listed on your slip of paper, which are also on the card. Do your checking aloud so that I may follow you. Start with number of borders. (E check that S follows the sequence given on the slip and checks all attributes.) Do you understand that any card you would have chosen would have all the 7 attributes ? Do you have any questions on the 7 attributes contained on each card ?

"Now let us define what a concept is on this board. Concepts on this board are stated in terms of one or more of the seven attributes. For example, all the cards containing circular figures form the concept, circles. Show me four cards which belong to this concept. (E wait until S points out four examples.) That's correct. Consider another example. All the cards with small, red, elliptical figures form the concept 'small, red, ellipses.' Show me four cards which belong to the concept, 'small, red, ellipses.' (Again E make sure S knows four examples of 'yes-cards!) That's correct. A very large number of concepts can be formed, having one, two, or any combination of the 7 attributes that are listed on your slip of paper. Please state a one-, then a two-, and then a three-attribute concept. . . That's fine. In this experiment, your job is to attain concepts of the type we have just discussed. Do you have any question about what a concept is ?

"Listen carefully now to the procedure for attaining a concept that I have in mind. I shall indicate one card which belongs to the concept. This card we shall call the focus card. This focus card contains all 7 attributes, and part of these 7 attributes form the concept I have in mind. Your job is to test attributes of other cards in relation to the focus card to determine which attributes form the concept. (Some cards contain all the attributes that form the concept, others do not.) Read off the number of the card you are checking and I shall tell you 'yes' if all the attributes that define the concept are present on the card and 'no' if one or more of the attributes that define the concept are not present on the card.

"The best way to ascertain the concept is to select your successive cards so that each card is exactly like the focus card, except for one attribute. Let us start with card 168 (4, 7) as an example of a focus card. To check the attribute, number of borders, we may go to card #61 (8, 7). Note that card #61 is exactly like the focus card except for the number of borders. To check the type of border we might go to card #95 (2, 7). Note that card #95 is exactly like the focus card except for type of border. Referring to your slip of paper, you tell me a card that differs by one attribute only for each of the five remaining attributes listed. Start with number of figures, (6-no. of figures, 48-size, 88-texture, 105-color, 12-shape.) You have just finished varying all seven attributes, one at a time, from the focus card. You should note that the cards which vary one attribute lie in the same row or column as the focus card. Do you have any questions about how to vary the 7 attributes, one at a time, from the focus card?

"If you had been trying to attain a concept of one or more attributes for which card #163 was the focus card, you would have proceeded in exactly the same manner. However, to some of your card choices I would have responded with 'yes' and to others 'no.' On the basis of all the 'yeses' and 'nos' you could have determined the concept I had in mind.

"You must test all 7 attributes listed on your slip of paper to be certain you get the correct concept. When you think you know the concept and have it marked on the slip of paper, give it to me. If the concept is correct, the task is completed. If not, I'll simply say 'not correct, continue' and you will continue selecting cards until you again offer a concept. Use the slip of paper at all times and take it to the board with you.

"Your job is to ascertain the correct concept as quickly as possible. Do you have any questions?"

THE PRINCIPLE

"To get any concept I have in mind, you must use both the 'yes' and 'no' cards and there is an important principle to learn. The principle is that when you vary one attribute from the focus card and I give you a 'no,' the attribute of the focus card varied is part of the concept. When you vary one attribute from the focus card and I give you a 'yes,' the attribute is not part of the concept. For example, suppose #168 is the focus card and you select #61 (8, 7) which is like #168 except that it has two borders. If I said 'no' to card #61 you would know that one border is part of the concept since the focus card is exactly like #61 except it has one border. However, if I had said 'yes' to #61 you would know that number of borders is not part of the concept since it makes no difference that #168 has one border and #61 has two borders. Let us try another example. Suppose #168 is the focus card and #12 is a 'no' card. What does this tell you concerning the concept? . . . Circle is part of the concept since this is the only attribute varied from card #168.

"This principle involving my giving you a 'no' applies only when one attribute is varied from the focus card. Suppose I respond 'no' to card #36 (4, 11). You could infer nothing about the concept. Can you tell me why? Correct. Because two attributes from the focus card were varied; size and texture. Do you have any question about how to use the principle to use the 'no' cards to determine the concept?"

The subjects reported to the Learning Laboratory individually. After a brief introduction with the experimenter, the instructions were administered. No help or suggestions of any type were given, except that for the conservative instructions both with and without the principle, the experimenter pointed out to the subject the method for varying one attribute from the focus card at any time when he was not doing so.

Time in seconds from the end of the instructions until the S attained the concept was kept with a stop watch. During a class period of fifty minutes, each S received instructions and attained as many concepts as he could. Some Ss attained only four concepts; therefore the analysis of variance was run on the total time in seconds which each subject used to acquire the first four concepts. Two Chi-square analyses were computed. A Chi-square test was run on the incidence of Ss who did not complete four concepts in fifty minutes, according to the six treatments. Another analysis was made by counting the number of concepts attained by subjects in each of the six treatments, and these incidences were submitted to a Chi-square test.

Results

In Table 37 are presented the mean times in seconds and standard deviation units for each of the six groups. The minimal instructions without the principle took the most time, the conservative instructions without the principle was second, the minimal instructions with the principle was third, and least was the conservative instruction with the principle.

Table 37

Mean Time in Seconds and Standard Deviations for Six Groups, According to Instructions and Principle

Treatment	Structure		Conservative		Minimal		Grand Mean
	Mean	SD	Mean	SD	Mean	SD	
With Principle	1215.77	474.65	855.29	377.59	1291.12	488.78	1120.73
Without Principle	1273.77	525.52	1315.18	703.65	1580.53	596.55	1389.83
GRAND MEAN	1244.77		1085.24		1435.82		

Table 38 shows the summary analysis of variance. The F-ratio for principle-not principle was 6.63, significant between the .05 and .01 level. The F-ratio for instructions was 3.78, also significant between the .05 and .01 level. The interaction term was not significant. As may be seen in Table 37, the minimal instructions were least efficient; the instructions explaining structure were second; and the conservative instructions were most efficient. Also shown in Table 37 is the considerable difference in time-to-criterion for instructions with and without the principle.

Table 38

Summary ANOVA on Total Time in Seconds for Four Concept Attainment Problems

Source	SS	df	MS	F
Principle	1,846,551	1	1,846,551	6.63*
Instructions	2,107,587	2	1,053,793.5	3.78*
Interaction	679,228	2	339,614	1.219
Within cells	26,743,175	96	278,574	
Total	31,376,541	101		

*$.01 < p < .05$

In Table 39 are presented the results of a Duncan Multiple Range Test. Only the difference between the minimal and conservative instructions was significant at the .05 level.

Since the procedures allowed the Ss to solve as many problems as possible, up to a maximum of ten, during the 50-minute experimental period, it was interesting to tabulate the number of problems solved for principle and without principle under three sets of instructions. In Table 40 are presented the total number of problems for all conditions and the total number solved for principle and without principle and for the three sets of instructions.

Table 39

Total Number of Problems Solved Using Three Types of Instructions With and Without the Principle

	Structure	Conservative	Minimal	Total
With Principle	149	161	138	448
Without Principle	146	126	131	403
Total	295	287	269	

As can be observed from Table 40 more problems were solved by Ss when they received the principle than when they did not. Also, fewer problems were solved by Ss under minimal instructions with Ss receiving conservative and structure instructions being much alike and solving more problems. However, a Chi-square yielded a value of 2.06, not significant at the .10 level.

A minimum of four problems completed was set as the criterion for keeping a S in the experiment. Ss who did not meet this criterion were replaced at random from a pool of Ss that were not previously assigned to the experiment. The data for the Ss who did not meet the criterion were kept. In Table 41 are presented the number of Ss who were dismissed from the experiment under the three sets of instructions with and without the principle.

Table 40

Duncan Range Multiple Comparison Test

		Conservative	Structure	Minimal
	Mean	1085	1245	1436
Conservative	1085	--	--	--
Structure	1245	160	--	--
Minimal	1436	351*	191	--

*Significant between .05 and .01 level

Table 41

Incidence of Subjects Dropped from Experiment, According to Instructions, With and Without Principle

	Structure	Conservative	Minimal	Total
With Principle	8	3	5	16
Without Principle	2	12	2	16
Total	10	15	7	32

The number of Ss eliminated (16) was the same with and without the principle for the three sets of instructions. A Chi-square value of 10.30 was obtained for the data in Table 41, significant at the .01 level. The greatest number of Ss eliminated came from conservative instructions; and here the large number was without the principle. A Chi-square test on the totals for the three types of instructions yielded a non-significant value, 3.06. Thus, the significant value for the six entries resulted primarily from the fact that under minimal and structure instructions most persons were dismissed who had received the principle; whereas the reverse was true for those who had received the conservative instructions.

RELATED EXPERIMENT: EFFECTS OF SELECTED VARIABLES UPON INFORMATION PROCESSING AND INFORMATION UTILIZATION IN CONCEPT ATTAINMENT FOR YOUNGER SUBJECTS

This experiment was conducted during the second semester of the academic year, 1962-63.

Purposes

The primary purpose was to determine the effects and difficulty characteristics of selected variables on information processing and information utilization during concept attainment. The specific questions regarding information processing were:

1. What are the effects of the following three variables upon information processing: a treatment variable—instruction or no instruction, a stimulus variable—ordered or random stimulus display, and a stratifying variable—male or female Ss?

2. What are the difficulty characteristics of the following item types on information processing: exemplars or non-exemplars of concepts which potentially convey an equal amount of information and two complexities of stimulus presentation which present equivalent information about a concept?

3. What are the difficulty characteristics of the following response options in information processing: Inclusion-exclusion or indeterminateness

of a card to membership in a group of cards exemplifying a concept. The specific questions regarding information utilization were:

1. What are the effects of the following three variables upon information utilization: instruction or no instruction, ordered or random stimulus display, and male or female Ss?

2. What are the difficulty characteristics of three complexities of information presentation on information utilization?

3. What are the difficulty characteristics of serial presentation of two problems in information utilization?

Information processing was specifically defined in this study as the ability of a S to specify the belonging, exclusion, or indeterminateness of a card to membership in a group of cards which exemplify a concept, given other cards for which membership is determined.

Information utilization was specifically defined as the ability of a S to utilize information in determining a concept or underlying rule for classification of cards on a stimulus display into two groups, one which exemplifies the concept, the other not doing so.

Subjects

The Ss for this study were randomly drawn from the population of undergraduate and graduate students enrolled in educational psychology courses at the University of Wisconsin. A total of 72 students — 36 males and 36 females — took part. This stratified sample was randomly assigned to the various treatments and participated in both experiments in order to determine answers to the questions cited previously. The Ss were in the 20-25 age range with modal ages of 22 for males and 21 for females.

Experimental Materials

The principal materials used in this experiment were the 64 RF and 64 OF. In addition, a small display consisting of 8 cards and a different type of stimulus material was used in giving the Ss directions about the information processing task. Also four types of card markers were available on the table for the S's use. These consisted of capital letters cut out. A "Y" was used to designate an exemplar of a concept, an "N" was used in designating a non-exemplar, and an "F" was used to designate a focus card. A question mark cut-out was also used to designate the test card.

The concept attainment tasks were of the type involving conjunctive concepts.

Experimental Procedure

The S was scheduled to report at his convenience to the Learning Laboratory. Upon arrival he was told of the general nature of the experiment and that after the experiment was finished he would be given an opportunity to ask questions. The S was also requested not to divulge the nature of the experiment to another person since this might influence the results. Then the S received his instructions and participated, according to the experimental design. That part of the experiment dealing with information processing consisted of the S responding to 60 items. The first 30 were of the type in which one card, either an exemplar or a non-exemplar, was presented in addition to the exemplar focus card.

The task was to specify the inclusion, exclusion, or indeterminateness of a third card to membership in a group of cards exemplifying a concept. The problems in which exemplars were presented numbered 15 and those presenting non-exemplars also 15. Of these 15 exemplar items, ten cards whose membership was to be determined were definitely exemplars of the same concepts as the focus card. The membership of the remaining 5 test cards could not be determined. In the 15 problems presenting a focus card and a non-exemplar, 10 test cards were definitely not exemplars and five were again not determinable. Thus these 30 items could be scored on the basis of the information presented—15 exemplars and 15 non-exemplars; and they could also be scored on the basis of test membership exemplar, non-exemplar, and indeterminate.

The second set of 30 items was constructed, using the same focus card and test cards as in the first subtest. The information presented in addition to the exemplar focus card consisted of two cards instead of one as was the case with the first subtest. One of the two cards for each problem was an additional exemplar; the other was the same in kind as its counterpart in the first 30 items. The answers to the 30 items of the second subtest were identical to those in the first subtest. Thus, the two subtests were the same except that the information presented about the test card in the second subtest included the additional complexity of one card.

Each S̲ attempted to solve the 60 problems following the appropriate instructions, and on the basis of the number correct and a subsequent statistical analysis, conclusions were arrived at in connection with variables affecting information processing.

A quite different type of situation was arranged to determine the effect of selected variables on information utilization. Two problems were arranged in which enough information was presented for a S to attain or determine the concept. The S's task in the experiment was to utilize this information in ascertaining a concept.

The concepts to be attained were of three- and four-relevant attributes. For each concept, three complexities of stimulus material were presented. These complexities were: six cards which varied from a focus card by one attribute; less than six cards which presented the previous six bits of information, the equivalence being exemplars; and the combination of all the cards presented to both groups. This created a group which received redundant information.

The instructions to the Ss for attaining these two concepts in sequence also provided markers for the S to identify the card to be used when attempting to attain the concept.

In the first part of the study dealing with information processing, a 2 × 2 × 2 factorial, repeated measurement design was used to control the effects of training, sex, ordered or random stimulus arrangement, exemplar or non-exemplar presentation, and two complexities of information presentation. In that part of the experiment dealing with information processing the effects of training, sex, ordered and random arrangement, and three complexities of information presentation were analyzed in a

2 × 2 × 2 × 3 factorial, repeated measurement design.

On the information processing, two analyses were performed on the scores of the sixty problems, resulting from two different scoring procedures. For the first analysis, dichotomized subtest scores and the total score were recorded for each individual. These part scores were based on the number of items correct of the 15 items when exemplar or non-exemplar card presentations were made in each of the two subtests. For the second analysis the responses were rescored on the basis of the number correct which tested the card's inclusion, exclusion, or indeterminateness in relation to the concept exemplified by the focus card or by the focus card and other exemplars.

For information utilization, time-to-criterion scores for the two concepts were analyzed by analysis of variance. Also Chi-square tests were performed on frequencies of hypothesizing concepts. Finally, product-moment correlations between the total scores from the information processing and the time-to-criterion scores for information utilization on each were run.

Table 42 shows the Hoyt internal consistency reliability estimates based on the various ways of scoring the Ss' responses to the first 60 items. The coefficients range from .49 to .72. Although these coefficients are not as high as desired, they are sufficiently high for the purposes of comparing the performances of the groups in this experiment.

Table 42

Hoyt Internal Consistency Reliability Estimates Based on Five Analyses

Analysis Criteria	Reliability Coefficient
Total Test Score	.70
Subtest One Score	.56
Subtest Two Score	.55
Exemplar Sub Score	.72
Nonexemplar Sub Score	.49

Results

Table 43 presents the results of the ANOVA performed on the exemplar, non-exemplar stimulus presentation scores dealing with information processing. Seven sources of variance resulted from three row effects and their interactions. None of these sources were significantly different from zero at the .05 level. A second part of the ANOVA performed on the same exemplar, non-exemplar stimulus scores showed an F-ratio of 5.08 between the repeated measures. A third part of the analysis dealt with the interactions. The F-ratio was not significant.

Table 44 shows a further analysis of the repeated measures from the ANOVA of exemplar-non-exemplar stimulus presentation. The F-ratio of 6.33 for subtests and a comparison of mean scores shows the second test to be significantly more difficult than the first. The subtests by exemplar-non-exemplar interaction was also significant. The exemplar items in the second subtest were significantly more difficult than the non-exemplars in both subtests as well as the exemplar items in the first subtest. The means for the four interaction cells were: subtest one, exemplar, 18.22; subtest one, non-exemplar, 18.25; subtest two, exemplar, 16.00; and subtest two, non-exemplar, 18.25.

Table 43

Analysis of Variance of Scores Based on Exemplar-Nonexemplar Stimulus Presentation

Source	SS	df	MS	F
Treatments (T)	103.21	7	14.74	1.47
Ss/T	642.44	64	10.04	
Repeated Measures (RM)	67.78	3	22.59	5.08*
T × RM	103.21	21	4.91	1.10
Ss/T × RM	854.01	192	4.45	
Grand Mean	22507.35	1		
TOTAL	24278.00	288		

F-Ratio with seven and 64 d.f.: 5 percent 2.15, 1 percent 2.93
F-Ratio with one and 192 d.f.: 5 percent 3.89, 1 percent 6.76
F-Ratio with 21 and 192 d.f.: 5 percent 1.62, 1 percent 1.97

*p < .05

Table 44

Difficulty Characteristics of Repeated Measures from Analysis of Variance Based on Exemplar-Nonexemplar Stimulus Presentation

Source	SS	df	MS	F
Subtest (S)	22.21	1	22.21	6.33*
Ss/T × S	224.67	64	3.51	
Exemplar (E)	23.44	1	23.44	3.33
Ss/× E	451.67	64	7.06	
S × E	22.13	1	22.13	7.96**
Ss/T × S × E	177.67	64	2.78	

F-Ratio with one and 64 d.f.: 5 percent 3.99, 1 percent 7.04

*p < .05

**p < .01

Table 45 presents results of the second analysis of variance performed dealing with information processing. The significant F-ratio for response mode results from the following means: definitely "yes" cards, 12.94; definitely "no" cards, 14.13; and indeterminate cards, 18.29. The items based on responses for cards where the membership was indeterminate were significantly more difficult than for those where the response was either "yes" or "no," definitely. The subtest dealing with definitely "yes" and definitely "no" were not significantly different from each other.

Table 45

Analysis of Variance of Scores Based on Response Options

Source	SS	df	MS	F
T	137.46	7	19.64	1.47
Ss/T	856.76	64	13.39	
Response Options (RO)	1369.67	2	684.84	39.59*
T × RO	242.40	14	17.31	1.00
Ss/T × RO	2214.93	128	17.30	
Grand Mean	30009.80	1		
TOTAL	34831.00	216		

F-Ratio with seven and 64 d.f.: 5 percent 2.15, 1 percent 2.93

F-Ratio with one and 128 d.f.: 5 percent 3.92, 1 percent 6.84

F-Ratio with fourteen and 128 d.f.: 5 percent 1.77, 1 percent 2.23

*$p < .01$

Table 46 presents the results of the ANOVA of time-to-criterion scores for information utilization in concept attainment. Four treatment effects and their interactions were computed from the row sources of variance. In addition to the ordered and random stimulus, instruction and no instruction, and sex, the effects of three modes of card presentation were analyzed. These modes of card presentation employed as follows: six cards, exemplars and non-exemplars, each varying one attribute from the focus card, and the focus card; non-exemplars varying one attribute from the focus card, one exemplar varying four attributes and another varying three attributes from the focus card and the focus card; all the non-exemplars, the exemplars, and the focus card used in the previous two modes. These three modes of presentation are indicated in Table 46 by the term, k-values. As may be observed in Table 46, the only significant main effect was instruction. The mean time for the instructed group was 1.31 minutes; the mean time for the non-instructed group was .98 minutes, this difference being significant at the .05 level. Thus, the special instructions, using a different type of stimulus material, had an inhibitory effect on performance in attaining concepts.

The ordinal position of the concepts to be attained was also significant at or beyond the .01 level. The first ordinal position was more difficult than the second ordinal position, the mean time for the first being 3.33 minutes and for the second 1.40 minutes.

Table 46

Analysis of Variance of Time in Minutes for Concept Attainment Problems

Source	SS	df	MS	F
Stimulus (St)	6.74	1	6.74	1.64
Instruction (I)	22.08	1	22.08	5.39*
Sex (Sx)	10.41	1	10.41	2.54
k-Values (k)	21.83	2	10.91	2.66
St × I	0.00	1	0.00	0.00
St × Sx	0.15	1	0.15	0.04
St × k	0.98	2	0.49	0.12
I × Sx	3.36	1	3.36	0.82
I × k	14.10	2	7.05	1.72
Sx × k	1.33	2	0.67	0.16
St × I × Sx	13.77	1	13.77	3.36
St × I × k	23.69	2	11.85	2.89
St × Sx × k	3.65	2	1.83	0.45
I × Sx × k	7.03	2	3.52	0.86
St × I × Sx × k	1.87	2	0.94	0.23
Ss/Treatments	196.93	48	4.10	
Ordinal Position (OP)	134.99	1	134.99	50.37
T × OP	55.85	23	2.43	0.91
Ss/Treatments × OP	128.85	48	2.68	
GRAND MEAN	801.64	1		
TOTAL	1445.25	144		

F-Ratio with one and 48 d.f.: 5 percent 4.04, 1 percent 7.19

F-Ratio with two and 48 d.f.: 5 percent 3.19, 1 percent 5.08

F-Ratio with 23 and 48 d.f.: 5 percent 1.74, 1 percent 2.20

*$p < .05$

Table 47 shows the results of Chi-square tests performed on the number of concepts offered within the five selected variables taken two at a time—stimulus, instructions, sex, k-values, and ordinal position. None of these values are significant at the .05 level, indicating that an equal number of concepts were offered by males, females, instructions, no instructions, etc. Finally the rs between the scores obtained from information processing and time-to-criterion for concept attainment were computed. The r between test score for information processing and time-to-criterion with the first ordinal position was -.22, significant at the .05 level, using a one-tailed test. Higher scores in information processing were associated with faster concept attainment. The r between the total test score and time-to-criterion for the second concept was -.13. This is not significant at the .05 level.

Table 47
Values of Chi-Square Tests on Frequency of Offering Concepts

Source	df	Chi Square Value	Level of Significance
Sex and Ordinal Position	1	.06	NS
Sex and Stimulus	1	1.79	NS
Sex and Instruction	1	.05	NS
Ordinal Position and Stimulus	1	.17	NS
Ordinal Position and K-value	2	2.26	NS
Stimulus and Instruction	1	.07	NS
Sex and K-value	2	.04	NS
Stimulus and K-value	2	.10	NS
Instruction and K-value	2	1.29	NS
Instruction and Ordinal Position	1	.06	NS

Critical Value of Chi-square for .05 level: One degree of freedom - 3.84
Two degrees of freedom - 5.99

CONCLUSIONS AND DISCUSSION

In this project five hypotheses were tested. In this abstract each hypothesis is stated and the conclusions pertaining to it are reported and discussed. Finally, conclusions not directly bearing on the five hypotheses are presented.

1. The Strategies Which Individuals and Groups Use In Attaining Concepts Are Related to Efficiency of Attaining Concepts.

This hypothesis was upheld for individuals in five experiments and for pairs and quads in two experiments; it was not rejected in any experiment. It was upheld using concepts embedded in three types of stimulus material—figural, semantic of low meaningfulness, and semantic of high meaningfulness. As will be reported later, variables based on tests in the cognitive and affective domain did not correlate significantly with efficiency of concept attainment, thus providing further evidence of the importance of strategies in concept learning.

Bruner et al. (1956) had hypothesized that individuals would use any of four ideal selection strategies, depending upon situational variables. Byers (1961) found that these four ideal strategies must be reduced to two strategies since two sets of two each were identical. Therefore, Bruner's ideal selection strategies were abandoned, as was also the idea of individuals varying their strategies according to situational characteristics. Instead, situational variables, such as type of concept, instructions, and other experimental variables were held constant within each experiment. In these experiments in which situational variables were held constant the efficiency of various strategies that were identified by the researchers was determined.

The general order of efficiency of five strategies, from most to least efficient, was Gambling h, Conservative a, Conservative b, Gambling i, and Conservative c. When using Gh, the S attained the concept on the first try without testing all the attributes prior to attaining the correct concept; he selected, cognized, and remembered information well, and he made the correct inference. When using Ca, the S carried out all the processes as in Gh but he also tested all the attributes prior to offering the correct concept on the first try. Cb strategy is the same as Ca except that in Cb the S made more redundant choices than was the case in Ca. The inefficient strategies Gh and Cc were characterized by poor cognizing of information, or remembering it, or inferring. The ratio of most efficient strategy to least efficient strategy was about 5:1.

Although the efficient Gh strategy was more efficient than Ca, the S correctly guessed the nature of the concept when using Gh. When he did not guess correctly, he used the inefficient Gi. However, when using Ca, the S could be sure that the first hypothesis offered was the correct one. Therefore, with the type of stimulus material used in the present experiment, Ss would probably perform best when using the Ca strategy consistently.

The strategy identification system used in the present experiment was appropriate for the type of stimulus material. It would undoubtedly be necessary to devise other systems for the various school subject fields. Nevertheless, the results of these experiments indicate that the different strategies result in greatly different performances. Toward the conclusion of this project, the strategy identification system was considered inadequate, although a marked improvement over Bruner's system. As further research is conducted, we shall first attempt to identify and clarify the processes in concept learning and then attempt another identification system for global strategies.

The system of strategy identification in the present experiments was given previously. In Figure 3 which follows, a tri-level, hierarchical arrangement for the identification of strategies is outlined. The global process which controls the sequence of events in attaining a concept, whether called a strategy, plan, method, or something else, should be sufficiently comprehensive to explain the individual's behavior from the first selection of an instance for testing, through the various steps in information processing, to the final inferring after the concept has been abstracted.

2. The Strategy Used by an Individual and Group Changes with the Type and Meaningfulness of the Material in Which the Concepts Are Embedded—Figural of Low Meaningfulness, Semantic of Low Meaningfulness, and Semantic of High Meaningfulness.

In one experiment involving individuals this hypothesis was upheld; and

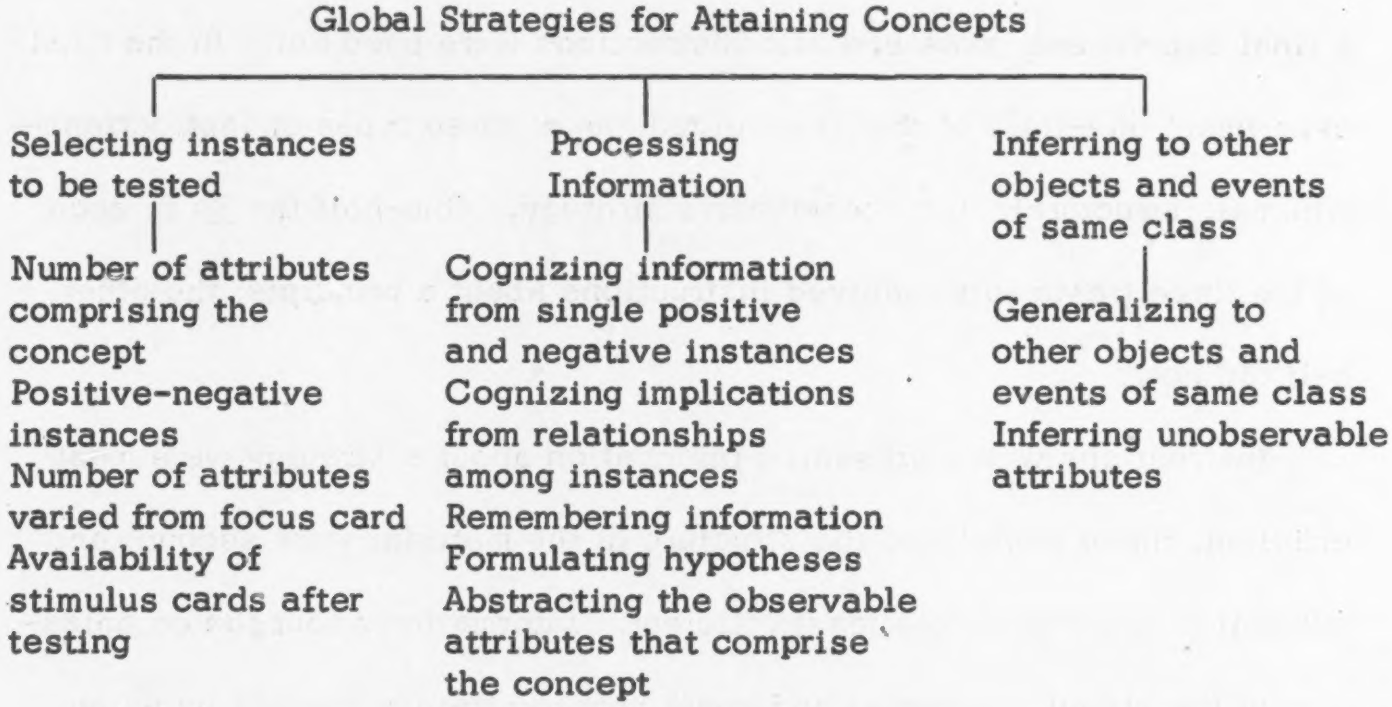

Global Strategies for Attaining Concepts
Selecting instances to be tested
Processing Information
Inferring to other objects and events of same class
Number of attributes comprising the concept
Positive-negative instances
Number of attributes varied from focus card
Availability of stimulus cards after testing
Cognizing information from single positive and negative instances
Cognizing implications from relationships among instances
Remembering information
Formulating hypotheses
Abstracting the observable attributes that comprise the concept
Generalizing to other objects and events of same class
Inferring unobservable attributes

Fig. 3. Tri-Level Hierarchical Arrangement of Process Variables to Explain Concept Learning.

in another involving groups of two, it was rejected. The incidence of the five strategies in attaining concepts was significantly different for individuals when the concepts were embedded in figural material, semantic material of low meaningfulness, and semantic material of high meaningfulness. The difference was not significant for groups of two. Individuals tended, in comparison with groups, to use the Gi strategy more frequently and the conservative strategies less frequently with figural stimulus material.

3. Type of Instructions and Knowledge of a Principle Affect Efficiency of Learning Concepts.

In all except two experiments, the Ss were given only minimal instructions concerning how to attain the concept which the E had in mind and for which he gave the S the initial focus card. In an exploratory and a final experiment, more specific instructions were tried out. In the final experiment one-third of the Ss received one of three types of instructions—minimal, structural, and conservative strategy. One-half the Ss in each of the three treatments received instructions about a principle; the other half did not.

Instructions which presented information about a strategy were most efficient; those explaining the structure of the material were second; and minimal instructions were least efficient. Information about the organization of the stimulus material and about how to attain a concept by using the algorithmic, conservative strategy was incorporated in the conservative strategy instructions in the present experiment. (The organization or structure had to be presented in order to teach the use of the conservative strategy.)

Previous research regarding the effect of instructions generally is unclear. French (1954) and Underwood and Richarson (1956) reported that instructions resulted in improved performance. Laughlin (1964) instructed one group to attain concepts as quickly as possible, regardless of the number of card choices. A second group was instructed to attain concepts with as few card choices as possible, regardless of time. The difference in the number of card choices was not significant; however, the difference in time-to-criterion was highly significant favoring the speed group, apparently resulting from the difference in instructions. Somewhat similar effects of instructions on originality test performance was found by Gerlach, Schutz, Baker, and Mazer (1964). Not all instructions improve performance. Archer, Bourne, and Brown (1955) found no significant difference between instructed and noninstructed Ss, although a significant interaction was reported. Tagatz (1963) found his instructions to have a negative effect on performance. Tagatz used one type of stimulus material for his instructions, another type for the concept attainment problems. Apparently, negative transfer resulted. Petre (1964) also secured negative transfer when using dissimilar stimulus material in a training situation. Thus, it is possible that the effect of instructions may be positive, negative, or neutral, depending upon the specific experimental instructions and materials.

Bruner (1961) proposed that the structure of knowledge is an important variable in learning; however, he did not explain what he meant by structure nor did he present experimental evidence concerning his assertion. In the present experiment, structure was defined as the relationship among the attributes and defining characteristics of each attribute, as may be inferred from examining the instructions given in Experiment 9. Information about the structure resulted in more efficient concept attainment than did minimal instructions but in less efficient performance than the conservative strategy. Thus, we may assume that information about the structure of knowledge facilitates performance but not so greatly as does knowledge of structure combined with knowledge of a procedure.

Ss who were provided information about the principle performed significantly better than did those who did not receive the information. This conclusion is in agreement with previous research by Judd (1908), Hendrickson and Schroeder (1941), Craig (1956), Kittell (1957), and Haselrud and Meyers (1958), but the research which follows presents somewhat different conclusions.

Hilgard, Irvine, and Whipple (1953) reported that knowledge of a principle (understanding group) resulted in improved transfer over rote memory of a task; however, the "understanding group" required more time to master the initial task. In the present experiment, time was started after the instructions were given; whereas Hilgard _et al_. included the time for learning the principle while solving the problems. This difference in method probably is the primary factor in accounting for the difference in results between the two experiments, for in the present experiments, the conservative instructions with the principle (the most efficient group) required more time to administer than did the other types of instructions with and without the principle.

Kersh (1962) taught two rules, or principles, by programed instruction until each _S_ applied the rules successfully to six problems. Subsequently, the _S_s were divided randomly into three groups. The directed learning group was taught the rules and their explanations by a programed learning technique in which small step sequences of explanations were learned. The guided discovery group was required to discover the explanation with guidance from the experimenter. The rote learning group received no explanations of the rules. The criterion was the number of _S_s from each group who used and stated the rules when solving two transfer problems.

In Kersh's study the rote learning group was found superior to the other two groups by the criterion used. This cannot be interpreted as showing that a principle is not effective for a number of reasons. All the Ss were taught the rules initially. Also, two different methods were subsequently used with the guided discovery and the directed learning groups. These methods may have interfered with subsequent learning, rather than facilitating it. Further, the criterion was the number of Ss who used and stated the rule. In the present experiments, half the Ss were given the same information regarding the principle; and the other half were given no information. Kersh would probably consider the principle group in the present experiments as similar to his rote group. However, the present experimenters did not have the Ss memorize the principles but did give instructions intended to facilitate understanding. Thus, the results of Kersh's study are not considered to be contradictory to the present study or to that of Hilgard et al.

The conclusions regarding this hypothesis cast some doubt upon the efficacy of learning by discovery. Ausubel (1961) drew a similar conclusion. If learning by discovery is to result in more efficient performance, apparently the situation should be so organized that the learner is given some cues concerning the principal units in the hierarchy of knowledge, and also some information as to how to interpret and manipulate various units of the structure. Wittrock (1963), considering instructions regarding procedures rather than those explaining structure, concluded that under certain conditions meaningful direction can supply distinctive verbal cues which increase the probability that the learner will respond in a directed fashion. He also suggests that the directions should match the criterion performance desired.

4. Attaining Concepts Initially As a Member of a Group, in Comparison with Attaining Them as an Individual, Results in Lower Efficiency When Attaining Subsequent Concepts Individually.

This hypothesis was tested in one experiment using 128 Ss. In the first experiment it was found that the difference among individuals, pairs, and quads for initial learning was significant beyond the .01 level. The rank order of efficiency for initial learning was quads, pairs, and individuals.

In a transfer problem which followed immediately after the initial learning, the difference among the individuals, pairs, and quads was significant between the .05 and .01 level. In this immediate transfer situation those who had learned initially as individuals performed significantly better than those who had worked initially as members of pairs or quads.

In the partial replication with half the Ss, the same rank order as in the first experiment was found on initial learning, namely, quads, pairs, and individuals. On the immediate transfer problem, individuals had a lower mean time than pairs or quads; however, the difference was not significant.

In summary, the hypothesis was upheld in the first experiment but not completely in the partial replication. However, in the replication with the smaller N, the individuals had the lower mean score on the transfer problem.

At the time this project was initiated, no transfer study in verbal learning involving individuals and groups had been located. Researchers had studied the performance of individuals and groups only in initial learning situations. The results of the present experiments regarding the relative efficiency of individuals and groups coincide with those reported in summaries by Lorge, Fox, Davitz, and Brenner (1958), Gurnee (1962), and Restle and Davis (1962). Individual investigations favoring group performance were reported by Watson (1928), Shaw (1932), Gurnee (1937), Thorndike (1938), Husband (1940), Klugman (1944), Perlmutter and DeMontmollin (1952), Taylor and Faust (1952), Lorge and Solomon (1955), Marquart (1955), Beasley (1958), Barnlund (1959), Faust (1959), Lorge and Solomon (1959), Lorge and Solomon (1960), Fox and Lorge (1962), Hoppe (1962), Tuckman and Lorge (1962), and Hall, Mouton, and Blake (1963).

In other studies by McCurdy and Lambert (1952), Maar and Anderson (1954), and Duncan (1959), the groups have not performed more efficiently than individuals. Duncan, particularly, has stressed in his review the superior performance of the best individuals over that of the groups. Wegner and Zeaman (1956) reported that the performance of groups of two and four was superior to that of individuals on a pursuit rotor task for both initial learning and transfer. Although transfer from doubles to singles equaled that from singles to later singles, transfer from quads to singles was not as great as that from singles to later singles. In the present experiments, the transfer performance of individuals who had initially learned as members of quads was much poorer than that of individuals who had previously worked singly.

The results regarding initial learning and transfer in the present experiments are similar but not identical to those reported by Hudgins (1960). With fifth-grade girls and boys, Hudgins found that groups of four solved more problems than did individuals in the initial learning situation; however, there was no significant difference in performance in the transfer situation between the Ss who had prior experience in groups of four.

Groups of sixes were also run in the replication experiment. Their performance was very similar to that of the quads. In part, this resulted because the experimental stimulus board and other elements of the situation did not permit six persons to participate actively in the attainment of concepts. Thus, the experiments did not provide an adequate test of the effects of group size of six.

5. Sex, Age, General Intellectual Ability, Divergent Thinking Abilities, and Major Fields of Study Are Related to Strategies Used and to Efficiency of Attaining Concepts.

Two experiments were run with younger Ss and one with older Ss in connection with this hypothesis. With the younger Ss the measures of convergent thinking—logical thinking and GPA—were not found to be correlated with strategies used nor with efficiency of attaining concepts. The same was true for older Ss, except that gpa was not obtainable. For both older and younger Ss the following six values from the Allport-Vernon-Lindzey Scale were found not to correlate consistently and significantly with strategies or time-to-criterion: theoretical, economic, aesthetic, social, political, and religious. The following divergent thinking abilities as measured by various tests were also found not to correlate consistently and significantly with strategies or efficiency of concept attainment: originality, spontaneous flexibility, conceptual foresight, cleverness, and ideational fluency. However, with both older and younger Ss and for males and females, there was a tendency for the divergent thinking tests to be related to efficiency of concept attainment but not to strategies.

The major field of study of the Ss was tested in two experiments with ANOVA. In one, a significant difference was found; however, with a larger N in a subsequent experiment the difference according to major fields was not significant. Further, the order of mean scores according to subject fields varied for concepts in which the Ss selected the instances for testing and for concepts in which the instances were presented. Thus, the relationship between major field of study and efficiency of concept attainment needs further study.

6. The Effects and Difficulty Characteristics of Selected Variables on Information Processing and Information Utilization during Concept Attainment.

The three variables tested in connection with information processing were: instructions—no instructions, ordered—random display, male—female. The difficulty characteristics of the following item types on information processing were determined: exemplars—non-exemplars, inclusion-exclusion—indeterminateness of a card to membership in a group of cards. The three variables tested in connection with information utilization were: instructions—no instructions, ordered—random display, male—female. The difficulty characteristics of the following types were ascertained: three complexities of information, serial presentation. Information processing was defined as the ability to specify the belonging, exclusion, or indeterminateness of a card to membership in a group of cards which exemplified a concept, given other cards of which membership is determined. Information utilization was defined as the ability to utilize information in determining a concept when the instances necessary for determining the concept are presented.

In connection with the problems dealing with information processing, the effects of instructions—no instructions, ordered—random display, and male—female were not significant at the .05 level. Also, the information contained in exemplar cards, or positive instances, was found to be more difficult to attain than that in non-exemplar cards. Finally, information was more difficult to obtain from cards whose membership was indeterminate than from cards which definitely did or did not belong to the concept.

Pertaining to information utilization, the ordered-random display and male—female variables were not significant at the .05 level.

Instruction—no instruction was significant at the .05 level. Ss who received no instructions performed better than did those who received instructions. The instructions, however, were administered with stimulus material quite different from that used to ascertain the effects of the three variables on information utilization. Another variable, complexity of the material, was not significant. Ordinal position effect was significant; the first concept to attain was more difficult than the second, indicating improved performance with practice.

The more complex the stimulus material, the more difficult is the information to process, as indicated above. A possible explanation of this is that the larger the number of cards presented, the larger the amount of irrelevant information. This is in agreement with the work of Bourne and Haygood (1959) and Archer, Bourne, and Brown (1955) who have shown that increasing the amount of irrelevant information impedes concept identification. The conclusion that information is more difficult to attain from positive or confirming instances than from negative or infirming instances is in contradiction with the conclusions of Hovland and Weiss (1953), and Glanzer, Huttenlocher, and Clark (1963) who reported greater efficiency of concept attainment with positive instances. However, Yudin and Kates (1963) and Kates and Yudin (1964) noted equal efficiency with positive and negative instances. Because of the small amount of work completed in the field of concept learning, the effectiveness of positive and negative instances in yielding information which Ss can process and utilize, further research appears essential. Possibly some combination of positive and negative instances results in most efficient learning.

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